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**U.S. Army Environmental Center**

U.S. Army
Environmental Center

# Pollution Prevention & Environmental Technology Division

*Innovative Technology Demonstration, Evaluation & Transfer Activities*

19990504060

# FY 1998 Annual Report

Distribution unlimited, approved for public release



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This report summarizes projects carried out during Fiscal Year 1998 (October 1997-September 1998) by the U.S. Army Environmental Center's Pollution Prevention and Environmental Technology Division. The report describes the projects, participants, results, requirements, milestones and products. P2&ETD conducts demonstrations of new and innovative environmental technologies and transfers successful technologies to the field. The division's experienced scientists and engineers handle projects in program areas such as environmental cleanup, compliance, pollution prevention, and conservation. Special initiatives carried out during FY 1998 included the multi-agency Range XXI program and the Tri-Service Site Characterization and Analysis Penetrometer System (SCAPS).

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# Introduction

This report contains information on projects "in progress" at the U.S. Army Environmental Center's Pollution Prevention and Environmental Technology Division (P2&ETD) during Fiscal Year 1998. These project summaries will help readers to better understand the division's work and capabilities.

Technology is a major weapon in the Army's efforts to defend the nation and sustain its environment. Through the programs described in this report, the U.S. Army Environmental Center (USAEC) gives the Army access to the most effective and affordable environmental tools available.

Adding the USAEC Pollution Prevention Branch to the Environmental Technology Division in FY 1998 – creating the Pollution Prevention and Environmental Technology Division – improved the Center's ability to help Army installations maintain readiness and meet environmental requirements through better business practices. The division also retained its focus on conservation, compliance and cleanup technologies, bolstering the Center's commitment to saving money and quickly putting innovative ideas to work for its Army and Defense Department customers.

## What's Inside?

The FY 1998 P2&ETD Annual Report is organized by the following categories:

- Pollution Prevention Programs
- Environmental Technology Programs
  - Cleanup Technology
  - Compliance Technology
  - Pollution Prevention Technology
  - Conservation Technology
  - Program Focus: Range XXI
  - Program Focus: SCAPS
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- Appendices

Project descriptions are organized into several sections:

| | |
|---|---|
| **Purpose** | What problem does the project address? |
| **Benefits** | How does the project help its users? |
| **Technology Users** | Who will use the technology? |
| **Description** | Why develop such a technology? How does it work? What is the development approach? |
| **Accomplishments and Results** | So far, what results have been achieved? |
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| **Follow-On Program Requirements** | What additional requirements are anticipated? |
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| **Program Partners** | What organizations are participating in the project? (Appendix B contains a consolidated list of partners.) |
| **Publications** | What publications relate to the project? |

*Section headings that do not apply to the project are omitted.*

**For More Information**

Want to know more about USAEC pollution prevention and environmental technology projects?

**Write** to t2hotline@aec.apgea.army.mil
**Call** the Army Environmental Hotline at (800) USA-3845
**Visit** the USAEC Web site at aec-www.apgea.army.mil:8080/

# POLLUTION PREVENTION PROGRAMS

P2&ETD program teams support initiatives to merge pollution prevention into Army missions, such as aiding efforts to buy and use materials that don't pollute the environment; integrating pollution prevention practices into training; fielding systems and methods to manage hazardous materials and reduce generation of hazardous waste; helping major commands and installations prepare and pay for P2 plans; and partnering with state and federal regulatory officials.

## AFFIRMATIVE PROCUREMENT

The Army needs various awareness vehicles to comply with Affirmative Procurement requirements mandated by federal laws, regulations and executive orders. The Affirmative Procurement awareness program will show the Army how to reduce solid waste, energy consumption, toxic materials and raw material usage – while stimulating the market for recycled-content products and encouraging use of new technologies.

**PURPOSE**

To establish and advance the acquisition and use of environmentally preferable products and services; to implement preference programs among the Army's requirements community; and to reduce the Army's solid waste stream.

**BENEFITS**

This program benefits both the Department of Defense (DoD) mission and the environment. It created the framework to reduce solid waste, energy consumption, and usage of toxic and raw materials. Reducing the use of toxic materials lessens effects on human health and the environment while decreasing the Army's hazardous waste stream. Affirmative Procurement stimulates the market for recycled-content products and encourages development of new technologies, quality products and services.

**TECHNOLOGY USERS**

All facets of the DoD community, including technical/requirements generators, procurement personnel, environmental offices, buyers, industry and education personnel.

## Description

Although program requirements are changing and expanding through Executive Order (EO) 13101 – which replaced EO 12873 – the requirement for an Affirmative Procurement program that includes reporting existed under Section 6002 of the Resource Conservation and Recovery Act (RCRA), the Solid Waste Disposal Act of 1976. The EO establishes implementation procedures for RCRA and directs federal agencies and their contractors to purchase recycled-content and environmentally preferable products (EPP) and services; review and revise federal and military specifications to enhance EPP purchasing; and consider environmental attributes (elimination of raw materials, waste minimization and prevention, toxicity reduction or elimination) in acquisition planning.

The Environmental Protection Agency (EPA) has designated 36 affirmative procurement items and their standards for federal purchasing. The Comprehensive Procurement Guidelines categories are paper, nonpaper products, vehicular, construction, transportation, parks and recreation, and landscaping. The Recovered Material Advisory Notice denotes each item and its minimum recovered-material content set by the EPA.

Affirmative Procurement is also codified in the Federal Acquisition Regulation. Army Regulation 200-1 places the Affirmative Procurement program under the scope of pollution prevention.

## Accomplishments and Results

As part of the awareness campaign, an Affirmative Procurement Web page was created in the second quarter of FY 1998. This Web page is structured to access relevant memorandums, the latest information on designated items, ordering and purchasing information, vendor and manufacturer sources, recommendations for successful word searches, and related training and conferences. An Army program brief and fact sheet are available for downloading.

The U.S. Army Environmental Center (USAEC) was part of a regional EPA pilot program for environmentally preferable purchasing. Many organizations, including Army major commands, EPA regions and the Professional Housing Manager's Association, have requested USAEC's assistance for FY 1999.

Platform presentations were given at two joint-service conferences, the National Recycling Coalition and the National Marketplace for the Environment. USAEC also delivered a joint presentation with the Defense Logistics Agency on re-refined oil and closed-loop recycling to the Army Test Center.

USAEC developed a fact sheet that describes the program and lists the current EPA-designated items. Articles were submitted for publication to various magazines. Soldiers Radio and Television conducted a live interview with Affirmative Procurement project officers at the 1998 Association of the United States Army conference.

### Follow-On Program Requirements

- Track program changes under EO 13101 and disseminate this information to the field through presentations, workshops, Web page updates, articles and fact sheets.
- Develop outreach products, including an Army Program Guide and a tabletop display of recycled-content products with statistics on solid-waste reduction.
- Provide Affirmative Procurement expertise – through workshops and presentations – to requesting organizations in FY 1999.

### Program Partners

U.S. Army Environmental Center
Office of the Director of Environmental Programs

### Point of Contact

Doenee Moscato

**PUBLICATIONS**

"Army 'Buys Green' to Prevent Pollution." *Environmental Update*. Summer 1998.

U.S. Army Environmental Center. *Fielding Environmental Solutions* (electronic mailing list). 1998.

*National Defense Magazine*. 1998.

*DPW Digest.* 1998.

## ◀ Emergency Planning and Community Right-to-Know Assistance

Defense Department installations will soon begin reporting munitions demilitarization activities under the Emergency Planning and Community Right-to-Know Act, or EPCRA. This project seeks to collect and place information on certain EPCRA toxic chemicals into a software package for installation use.

**Purpose**

To develop technical guidance for EPCRA reporting.

**Benefits**

Cost-effective and consistent EPCRA reporting.

**Technology Users**

Army and Department of Defense (DoD) installations.

**Description**

DoD has required EPRCA reporting of munitions demilitarization activities beginning July 1, 2000. This project seeks to identify EPCRA toxic chemicals in munitions and those released by munitions-demilitarization activities, and package this information in a software data-delivery system for installation use.

This effort is jointly funded by the Army, Air Force, Navy, Marine Corps and Deputy Under Secretary of Defense for Environmental Security.

**Accomplishments and Results**

The Range XXI program is developing accurate emissions data. Literature research and software evaluations are complete; design and populating of the database are underway.

**Follow-On Program Requirements**

Field the software and begin training (during FY 1999-2000).

**POINT OF CONTACT**

Mike Eck

**PROGRAM PARTNERS**

U.S. Army
U.S. Navy
U.S. Air Force
U.S. Marine Corps
Deputy Under Secretary of Defense for Environmental Security

**PUBLICATIONS**

*DoD EPCRA Data Source Evaluation Report*. January 1998.

*DoD Munitions EPCRA TRI Calculation Methods*. December 1998.

## ◀ Pollution Prevention Investment Fund

Army leadership has emphasized the need for installations to reduce environmental costs by preventing pollution. The Pollution Prevention Investment Fund (P2IF) helps installations pay for projects that reduce hazardous material use, cut hazardous waste disposal, and lessen the impact of environmental compliance requirements on Army operations.

**PURPOSE**

To provide a mechanism for allocating limited pollution prevention (P2) resources Armywide; to fund cost-effective installation-level P2 projects that support Department of Defense (DoD) P2 Measures of Merit; to reduce hazardous material purchase, use and disposal; and reduce or eliminate environmental compliance requirements.

**BENEFITS**

The fund allows Armywide P2 projects to compete evenly for limited resources. Through required reporting, the fund provides actual cost-benefit data for P2 processes. The fund identifies P2 processes that have potential Armywide applicability and assesses central procurement possibilities for these processes. The P2IF process also ensures that P2 funds are used for pollution prevention, and provides a way to identify P2 success stories.

**TECHNOLOGY USERS**

All Army activities (including Army Reserves and National Guard).

**DESCRIPTION**

The Army's Assistant Chief of Staff for Installation Management (ACSIM) continues to emphasize the need for installations to reduce environmental costs by focusing on compliance through pollution prevention. A method for achieving this goal is the P2IF. In 1997, the ACSIM directed the Office of the Director of Environmental Programs (ODEP) to execute the P2IF. The fund is directed by ODEP and administered by the U.S. Army Environmental Center (USAEC).

The P2IF is a centrally managed fund under which Army P2 projects compete for funding based on economic payback and other criteria. Required performance reports are used to analyze actual cost-benefit data versus cost-benefit estimates.

**ACCOMPLISHMENTS AND RESULTS**

In FY 1997, the P2IF disbursed $325,000 for eight projects. After the first year of operation, the fund reported actual cost avoidances of $890,000, reflecting an actual payback of .37 years. Two of the projects exceeded expectations by achieving payback faster than anticipated.

**LIMITATIONS**

Availability of funding limits the number of projects. All projects must be justifiable pollution prevention activities.

**FOLLOW-ON PROGRAM REQUIREMENTS**

Funding for FY 1999 is budgeted at $7.5 million. Program Objective Memorandum (POM) years 2000-2003 are programmed for at least $10 million per year.

**PROGRAM PARTNERS**

U.S. Army Environmental Center
Office of the Director of Environmental Programs

**POINT OF CONTACT**

Bill Nelson

**PUBLICATIONS**

P2IF guidance and information are provided on the USAEC Web page at:

aec-www.apgea.army.mil:8080/prod/usaec/et/p2/p2if.htm.

## ◀ Pollution Prevention Plans Review

Army installations and major commands must devise detailed plans to prevent pollution. The U.S. Army Environmental Center reviewed these plans to ensure their compliance with several Army and federal government requirements.

**Purpose**

To review Army installation and major command pollution prevention (P2) plans.

**Benefits**

Effective P2 plans ensure compliance with Executive Order (EO) 12856, Army Regulation (AR) 200-1 and guidance from the Assistant Chief of Staff for Installation Management (ACSIM).

**Technology Users**

Installation and major command staffs.

**Description**

USAEC staff reviewed plans from the major Army commands (MACOMs). Logistics Management Inc. reviewed installation plans in 1996.

ACSIM sent a memo to the MACOMs dated February 11, 1997, detailing ACSIM installation P2 plan elements and listing installation plans not in compliance. A second memo, dated February 10, 1998, required installation P2 plans to attain compliance with ACSIM guidance by June 1998. USAEC continues to monitor compliance.

**Accomplishments and Results**

P2 plans have been reviewed.

**Point of Contact**

Mike Eck

## THE HAZARDOUS SUBSTANCE MANAGEMENT SYSTEM

The Hazardous Substance Management System (HSMS) enables enable better management of hazardous materials through improved business practices at Army installations. As part of an overall pollution prevention and hazardous-material management program, HSMS can record, track and report on hazardous materials from procurement through disposal.

**PURPOSE**

To facilitate centralized hazardous-material control and management; and to assist with environmental reporting by tracking hazardous material from the time of request until it leaves an installation.

**BENEFITS**

Installations using HSMS while centrally managing and controlling their hazardous materials (HM) have reduced their HM inventories and improved personnel safety. Better business practices have helped many installations reduce hazardous waste (HW) and the associated disposal costs. Most installations that use HSMS have instituted stringent controls of HM along with shelf-life extension and material reuse programs. These initiatives have saved the Army millions of dollars.

**TECHNOLOGY USERS**

Department of Defense (DoD) facilities that handle enough HM and HW to require an automated tracking system.

**DESCRIPTION**

HSMS, part of the Defense Environmental Security Corporate Information Management (DESCIM) program, has been developed to enable better management of hazardous materials through improved business practices at Army installations. It is an automated system for tracking and reporting hazardous materials from procurement through disposal as part of overall pollution prevention (P2) and hazardous-material management programs.

In the late 1980s and early 1990s, commanders faced new environmental management and tracking requirements mandated by Executive Order 12856 and the Emergency Planning and Community Right-To-Know Act (EPCRA). They faced strict criminal liabilities under the Resource Conservation and Recovery Act (RCRA). DoD installations also discovered excessive HM/HW inventories, which led to high waste-disposal costs, unnecessary personnel exposures and a lack of HM visibility and control.

To address these problems, installations began developing nonstandard, ad hoc automated tools. The Department of Defense had to eliminate redundancy and unnecessary costs stemming from these less-than-optimal business practices and overlapping tracking systems, while enhancing pollution prevention and environmental compliance.

Army policy letters in 1995 and 1996 directed that HSMS would be the only authorized Army HM/HW/P2 tracking system. Army activities were to stop developing or buying commercially available software for tracking hazardous substances. As an interim measure, installations operating a system to control HM could use that system until HSMS was fully implemented. However, installations were to plan immediately for the transition to HSMS.

Early on, it was recognized that HSMS use alone did not save money or prevent pollution. Only when HSMS is used as part of an installation garrison commander's Hazardous Material Management Program (HMMP) are benefits realized.

An HMMP may be implemented in many ways. Generally, a centralized HMMP includes a management cell (known as a Hazardous Material Control Group) and a supply support activity for receipt, storage and issue. Some installations with smaller amounts of HM have opted for a "virtual" HMMP, with a central HSMS input site and limited physical control of HM. Others have implemented a "distributed" program, with several HSMS input locations and limited physical control of HM. Program management, however, stays centralized with all of these options.

This mission is not new; HMMP is an established regulatory requirement (Army Regulation 710-2). Centralization of HMMP functions through automation or physical location is essential to an effective program and saves Army resources.

HMMP is, above all, an installation commander's program. The functional contractors, funded by the U.S. Army Environmental Center (USAEC) and managed by the U.S. Army Corps of Engineers, support HMMP and HSMS by helping installations develop and implement their programs. As an additional resource, Army Headquarters published a Business Practice Guide that provides an overview of HMMP, describes eight potential business-practice initiatives and offers a model organizational approach for HM management.

**ACCOMPLISHMENTS AND RESULTS**

The Army began fielding HSMS to selected installations in early FY 1996. By the end of FY 1998, 20 sites across the country had achieved initial operational capability. By the end of FY 1999, it is anticipated that 37 sites will have reached initial operational capability. The current installation sequence list – developed by USAEC in consultation with the major Army commands – includes plans to field HSMS at more than 100 installations by the end of FY 2004.

**LIMITATIONS**

HSMS may not be a cost-effective option for smaller installations with nonindustrial missions.

**FOLLOW-ON PROGRAM REQUIREMENTS**

- Complete HSMS implementation at 37 Army installations by the end of FY 1999.
- Begin implementing HSMS at all applicable Army installations by the end of FY 2003.

**POINT OF CONTACT**

Stan Childs

**PROGRAM PARTNERS**

U.S. Army Environmental Center
U.S. Army Corps of Engineers
Program Executive Office, Standard Army Management Information Systems, HSMS Project Office

## ARMY 500

The Department of Defense requires weapon system program managers to implement hazardous materials management programs and pollution prevention programs. Army 500 is a management tool being developed to help program managers rank hazardous materials and make informed decisions regarding their use.

**PURPOSE**

To provide an automation tool that helps weapon system program managers (PMs) and staff collect information on hazardous materials and rank the materials based on human toxicity and environmental hazards.

**BENEFITS**

Army 500 will help program offices analyze hazardous materials and identify opportunities to eliminate the use of these materials. Reducing requirements for hazardous materials will reduce life-cycle costs for weapon systems.

**TECHNOLOGY USERS**

Program, project and product managers throughout the acquisition community, and environmental staffs at major commands and installations.

**DESCRIPTION**

Use of hazardous materials increases costs associated with occupational health and safety, as well as environmental liability. Requirements to implement hazardous materials management and pollution prevention programs compel PMs to identify the hazardous materials required in the design, manufacture and support of their weapon systems. Where possible, PMs must eliminate the need for hazardous material use or mitigate the environmental, health and safety impacts when elimination is impossible. Army 500 is designed to assist in the evaluation of hazardous materials for elimination.

Army 500 consists of an Excel spreadsheet, into which PM staffs can enter information on known hazardous materials and their applications. Once the data is entered for all

materials under consideration, the spreadsheet ranks the materials according to human toxicity and environmental hazard. Inputs to the spreadsheet include factors for permissible exposure limits, threshold limit values, reportable quantities, legislative risk, and treatment and disposal methods. The spreadsheet also considers costs and produces a rank-ordered listing with values assigned for each factor.

The spreadsheet will be made available to the acquisition community and other potential users on a World Wide Web site.

## Accomplishments and Results

Army 500 is near completion. The spreadsheet has been designed and is being revised to make it easier to use. A user's guide has been developed.

To demonstrate Army 500 and its capabilities, the U.S. Army Environmental Center has developed a sample spreadsheet using hazardous materials supplied by the Comanche program.

## Points of Contact

James Heffinger
Dean Hutchins

## Program Partners

U.S. Army Environmental Center
PM-Comanche

## COMANCHE HELICOPTER PROGRAM ENVIRONMENTAL LIFE-CYCLE COST ESTIMATE

The Department of Defense requires weapon system program managers to integrate environmental considerations into their acquisition strategies and include environmental costs in their program cost estimates. The U.S. Army Environmental Center has been asked to assist the Comanche program office and the U.S. Army Cost and Economic Analysis Center in the development of life-cycle environmental costs for the Comanche helicopter system.

**PURPOSE**

To develop and verify the environmental life-cycle costs for the Comanche helicopter system.

**BENEFITS**

By identifying program environmental cost elements, weapon system program managers (PMs) can make informed decisions on environmental issues by evaluating their impacts on long-term costs. Identification of environmental costs helps the Army develop more accurate and complete life-cycle cost estimates for weapon system acquisition programs.

**TECHNOLOGY USERS**

Program Executive Officer (PEO)-Aviation, PM-Comanche and the U.S. Army Cost and Economic Analysis Center (CEAC).

**DESCRIPTION**

In a 1997 audit, the Department of Defense (DoD) Inspector General found that environmental costs were not fully included in the Comanche program's cost estimates. In fact, the Inspector General found the Comanche cost estimate might be understated. As a result of the audit, PM-Comanche and CEAC requested U.S. Army Environmental Center (USAEC) assistance in identifying and estimating life-cycle environmental costs.

This project requires analysis of the entire acquisition plan for the Comanche helicopter program, identification of all activities with environmental impacts, and estimating environmental costs. Costs must be correlated to a work-breakdown structure for the program and documented using CEAC-approved cost-documentation formats.

Lessons learned from this and other projects will be included in an environmental cost handbook. The handbook will serve as a guide for program executive officers and PMs to estimate their programs' environmental life-cycle costs.

**Accomplishments and Results**

USAEC is nearing completion of this project. Face-to-face coordination with program office representatives, depot representatives and system users has helped USAEC identify all environmental activities and impacts. Final cost estimates are being derived.

PM-Comanche used the interim results of this project to respond to the DoD Inspector General. The results are also being considered as the Comanche program office and CEAC develop a final Army cost position for the program.

**Point of Contact**

James Heffinger

**Program Partners**

U.S. Army Environmental Center
U.S. Army Cost and Economic Analysis Center
PM-Comanche
Fort Campbell, Kentucky
Corpus Christi Army Depot, Texas

## ◀ Environmental Cost Handbook

The Defense Department requires program executive officers and program managers to integrate environmental considerations into their acquisition strategies and include environmental costs in their life-cycle cost estimates. Environmental life-cycle costing is a relatively new requirement, and little guidance is available to assist program executive officers and program managers. The *Environmental Cost Handbook* will describe how to identify and estimate life-cycle environmental costs for weapon systems.

**Purpose**

To develop a handbook that describes how to identify and estimate life-cycle environmental costs for weapon systems.

**Benefits**

Recognition of environmental costs will allow program executive officers (PEOs) and program managers (PMs) to evaluate impacts on life-cycle costs and make informed decisions on environmental issues.

**Technology Users**

PEOs, PMs, other acquisition officials and the U.S. Army Cost and Economic Analysis Center (CEAC).

**Description**

The U.S. Army Environmental Center (USAEC) is supporting the CEAC Weapon System Cost and Economic Analysis Division's project to develop and verify environmental life-cycle costs for Army weapon systems. This support has required close coordination with several weapon system program offices. USAEC confirmed there is no "how to" guidance available for identification and estimation of environmental costs.

The *Environmental Cost Handbook* is being developed to help PEOs and PMs figure environmental costs as independent values. The handbook will provide guidance in a way that allows PEOs and PMs to associate estimated costs with work-breakdown structure elements to support activity-based costing and performance monitoring.

The handbook will offer approaches for developing categories of environmental costs. For each environmental category or activity, potential sources of existing cost

information will be identified along with guidance for developing cost-estimating relationships. The goal is to provide guidance flexible enough to support the estimation of environmental life-cycle costs for most weapon systems.

### Accomplishments and Results

USAEC is nearing completion of an environmental life-cycle cost estimate for the Comanche helicopter program. Lessons learned, cost formulas, sources for environmental cost information and other elements are being documented for potential use in the handbook. Life-cycle cost estimating is about to begin for three other weapon systems; the results from these estimates will also be used in developing the handbook.

### Point of Contact

James Heffinger

### Program Partners

U.S. Army Environmental Center
U.S. Army Cost and Economic Analysis Center
PM-Comanche
PM-Apache
PM-Secure Mobile Anti-Jam Reliable Tactical Terminal
PM-Sense and Destroy Armor

## Longbow Apache Cost Analysis Working-Level Integrated Product Team Support

Weapon system program managers must integrate environmental considerations into their acquisition strategies and include environmental costs in their program life-cycle cost estimates. The Weapon System Cost and Economic Analysis Division of the U.S. Army Cost and Economic Analysis Center requested U.S. Army Environmental Center support in the development of environmental life-cycle cost estimates for the Longbow Apache upgrade program.

**Purpose**

To develop an environmental life-cycle cost estimate for inclusion in the Army cost position for the Longbow Apache system.

**Benefits**

Department of Defense regulations (DoD 5000.2-R) require program managers (PMs) to identify the life-cycle costs for their systems, including environmental costs. This project will help the PM for the Apache helicopter comply with this acquisition requirement. Identification of environmental costs will also help the PM make informed decisions on environmental issues by allowing him to evaluate the long-term costs of alternative courses of action.

**Technology Users**

PM-Apache, the U.S. Army Cost and Economic Analysis Center (CEAC), and the Longbow Apache Cost Analysis Working-Level Integrated Product Team (CA-WIPT).

**Description**

A portion of the A-model Apache fleet will be modified to the Longbow configuration. The new configuration includes mast-mounted fire control radar, a modified airframe and a radio frequency autonomous seeker in an upgraded HELLFIRE missile system. The PM must develop a program office estimate, which includes all life-cycle costs for the upgrade program. CEAC will develop an independent cost estimate to evaluate the accuracy of the program estimate. Differences in the two estimates will be arbitrated to produce a final recommended Army cost position. The U.S. Army Environmental Center (USAEC) will participate in this process by developing a life-cycle estimate for environmental costs. Both the PM and CEAC will use USAEC's environmental cost estimate.

USAEC will evaluate all phases of the acquisition strategy and identify activities with environmental impacts. Costs will be attached to environmental impacts and requirements; the total of all environmental costs will become the life-cycle environmental estimate. USAEC will coordinate closely with representatives from the program office, manufacturers and system users to identify all environmental activities. Costs will be documented using a work-breakdown structure developed specifically for the Longbow Apache program. Cost descriptions and methodologies will be documented using CEAC-approved cost-documentation formats.

Lessons learned from this and other projects will be used to develop an environmental handbook, which CEAC and the acquisition community can use to estimate environmental costs. The handbook will include descriptions of environmental cost elements, cost estimating methodologies, and recommended sources of cost information.

### Accomplishments and Results

On September 22, 1998, USAEC participated in the first meeting for the CA-WIPT. On November 16, 1998, USAEC staff attended an in-process review, during which the program staff discussed its planned methodologies for developing a program cost estimate.

### Follow-On Program Requirements

In January 1999, USAEC staff will visit the program office at Redstone Arsenal, Alabama, to create plans and schedules for developing the environmental cost estimates. USAEC then will examine program phases involving both government and contractor activities to identify all environmental elements.

### Point of Contact

James Heffinger

### Program Partners

U.S. Army Environmental Center
U.S. Army Cost and Economic Analysis Center
PM-Apache

Recent government audits of selected Defense Department acquisition programs revealed that compliance with the National Environmental Policy Act (NEPA) had not been properly factored into the acquisition management process. This manual will provide information to help program managers consider NEPA during materiel acquisition.

**PURPOSE**

To provide advisory information for integrating the requirements of NEPA and Army Regulation (AR) 200-2, *Environmental Analysis of Army Actions*, into the materiel acquisition process.

**BENEFITS**

This manual will simplify the NEPA process so program managers understand when to use a Categorical Exclusion (CX) or Record of Environmental Consideration (REC), an Environmental Assessment (EA) or Environmental Impact Statement (EIS), and feel comfortable with each approach.

**TECHNOLOGY USERS**

Department of Defense (DoD) program managers and program executive officers.

**DESCRIPTION**

NEPA requires the identification and analysis of potential environmental impacts of certain federal actions and alternatives before those actions can be initiated. The law also contains specific requirements for informing and involving other federal and state agencies and the public. NEPA requires a systematic, interdisciplinary approach to analyzing and considering environmental factors when planning or conducting federal agency programs and projects. The process for implementing the law is codified in Council on Environmental Quality Regulations, 40 Code of Federal Regulations (CFR) Parts 1500-1508.

Recent government audits revealed that NEPA compliance had not been properly factored into several DoD acquisition programs. This was likely due, in part, to the false assumption that NEPA is primarily of concern only to installation and facility engineers.

This manual will provide advisory information for integrating the requirements of NEPA and AR 200-2 into the

materiel acquisition process. The information will assist program executive officers (PEOs) and program managers (PMs) with the implementation of NEPA policies and procedures as they pertain to Army materiel acquisition. The manual is being developed as a "living" document, compiled in a loose-leaf format for convenient updating.

There is significant effort within DoD to reduce the number of mandatory policies, procedures and practices for the acquisition of weapon systems and other Army materiel. This manual will offer PEOs and PMs flexibility in satisfying the goals of NEPA.

## Accomplishments and Results

The coordinating draft of the *Acquisition NEPA Implementation Manual* has been completed. Department of the Army staffing of the manual for comment will be completed in December 1998.

## Follow-On Program Requirements

- Complete the draft final *Acquisition NEPA Implementation Manual* (January 31, 1999).
- Complete the final *Acquisition NEPA Implementation Manual* (February 26, 1999).

## Point of Contact

Louis Kanaras

## Program Partners

U.S. Army Environmental Center
U.S. Army Space and Missile Defense Command
Teledyne Brown Engineering

Department of Defense Regulation 5000.2-R requires that all programs, regardless of acquisition category, include a programmatic environmental, safety and health (ESH) evaluation in their acquisition strategy. The regulation does not set a format for this evaluation but requires it to describe a program manager's strategy for meeting ESH requirements, establishing responsibilities and tracking progress. Developing a guide for such evaluations will help program managers plan, execute and document actions that fulfill the ESH requirements of DoD 5000.2-R.

**PURPOSE**

To develop a guide for analyzing five specific environmental, safety and health areas: National Environmental Policy Act; Environmental Compliance; System Safety and Health; Hazardous Materials; and Pollution Prevention.

**BENEFITS**

The development of an ESH evaluation helps ensure those actions that fulfill the environmental, safety and health requirements of Department of Defense (DoD) Regulation 5000.2-R are planned, executed and documented.

**TECHNOLOGY USERS**

DoD program managers and program executive officers.

**DESCRIPTION**

DoD 5000.2-R requires that all programs, regardless of acquisition category, include a programmatic ESH evaluation in their acquisition strategy. The program manager must initiate the ESH evaluation at the earliest possible time in support of a program initiation decision (usually Milestone I) and update the evaluation throughout the program's life cycle.

The *Programmatic Environmental, Safety and Health Evaluation Guide* will help program managers meet these requirements by providing an approach for developing a comprehensive ESH evaluation. The approach will help ensure the development of an ESH evaluation that meets DoD requirements, and will make sure potential program "showstoppers" are identified and resolved early in the acquisition process. The evaluation will document the

program's ESH status, establish a process for monitoring changing compliance requirements, integrate ESH requirements into the program's acquisition strategy and other documentation, and establish a plan to meet future ESH requirements.

**Accomplishments and Results**

- Received and incorporated comments on the draft ESH guide.
- Developed coordinating draft of the ESH guide and distributed for comments.

**Follow-On Program Requirements**

- Obtain program executive officer comments.
- Obtain consensus of Army staff and field activities.
- Produce final ESH guide (incorporating all comments).
- Distribute final ESH guide.

**Point of Contact**

Louis Kanaras

**Program Partners**

U.S. Army Environmental Center
U.S. Army Space and Missile Defense Command
Teledyne Brown Engineering

## SADARM Cost Analysis Working-Level Integrated Product Team Support

The Department of Defense (DoD) requires weapon system program managers to integrate environmental considerations into their acquisition strategies and include environmental costs in their program cost estimates. The Weapon System Cost and Economic Analysis Division of the U.S. Army Cost and Economic Analysis Center requested U.S. Army Environmental Center support in the development and verification of environmental life-cycle costs for the Sense and Destroy Armor (SADARM) program.

**Purpose**

To develop and verify environmental life-cycle costs for the SADARM program.

**Benefits**

By identifying environmental costs, weapon system program managers (PMs) can make informed decisions on environmental issues by evaluating the impacts of these issues on long-term costs. Identification of environmental costs helps the Army develop more accurate and complete life-cycle cost estimates for weapon system acquisition programs.

Including environmental costs in program cost estimates also helps PMs comply with DoD 5000.2-R and other environmental laws and regulations. The U.S. Army Cost and Economic Analysis Center (CEAC) and the SADARM program office will use the results of this project to coordinate an Army cost position.

**Technology Users**

CEAC, PM-SADARM and the SADARM Cost Analysis Working-Level Integrated Product Team (CA-WIPT).

**Description**

Environmental issues and environmental costs are part of a program's decision review process. The SADARM program is preparing for a Milestone III (Production, Fielding, Deployment and Operational Support) decision review. In preparation for the review, CEAC requested that the U.S. Army Environmental Center (USAEC) assist with the development of environmental life-cycle costs for the SADARM program.

This project supports development of an independent cost estimate for a Milestone III Army Systems Acquisition Review Council (ASARC) review. The environmental life-cycle costs will be used to develop a final Army cost position for submission to the Army Cost Review Board before the ASARC.

USAEC will evaluate all phases of the acquisition strategy and identify activities with environmental impacts. Costs will be assigned to these environmental impacts and the total environmental cost will become the life-cycle environmental estimate. USAEC will coordinate closely with representatives from the program office, manufacturers and users to identify all environmental activities. Costs will be documented on a tailored work-breakdown structure and all costs will be further supported by individual cost-documentation formats.

Lessons learned from this and other projects will be used to develop an environmental cost handbook, which CEAC and the acquisition community can use to estimate environmental costs.

## Accomplishments and Results

This project is in the early stages. On October 16, 1998, USAEC staff attended an initial briefing and status update on the SADARM program. On October 21, USAEC participated in a pre-ASARC meeting on potentially restructuring the SADARM program to deal with operational test failures and funding difficulties.

USAEC has requested reports and program documents to begin the analysis process. USAEC also has coordinated nondisclosure agreements with the SADARM prime contractor to gain access to contractor information.

## Point of Contact

James Heffinger

## Program Partners

U.S. Army Environmental Center
U.S. Army Cost and Economic Analysis Center
PM-Sense and Destroy Armor

## SMART-T Cost Analysis Working-Level Integrated Product Team Support

The Department of Defense (DoD) requires weapon system program managers to integrate environmental considerations into their acquisition strategies and include environmental costs in their program cost estimates. The Weapon System Cost and Economic Analysis Division of the U.S. Army Cost and Economic Analysis Center requested U.S. Army Environmental Center support in the development and verification of environmental life-cycle costs for the Secure Mobile Anti-Jam Reliable Tactical Terminal (SMART-T) program.

### Purpose

To develop and verify environmental life-cycle costs for the SMART-T program.

### Benefits

By identifying environmental costs, weapon system program managers (PMs) can make informed decisions on environmental issues by evaluating the impacts of these issues on long-term costs. Identification of environmental costs helps the Army develop more accurate and complete life-cycle cost estimates for weapon system acquisition programs.

Including environmental costs in program cost estimates also helps PMs comply with DoD 5000.2-R and other environmental laws and regulations.

### Technology Users

The U.S. Army Cost and Economic Analysis Center (CEAC), PM-SMART-T and the SMART-T Cost Analysis Working-Level Integrated Product Team (CA-WIPT).

### Description

Environmental issues and costs are part of a program's decision review process. The SMART-T program is scheduled for a Milestone III (Production, Fielding, Deployment and Operational Support) decision review in late 1998. In preparation for the review, CEAC requested that the U.S. Army Environmental Center (USAEC) assist with the development of environmental life-cycle costs for the SMART-T program.

USAEC will evaluate all phases of the acquisition strategy and identify activities with environmental impacts. Costs will be assigned to environmental impacts and the total environmental cost will become the life-cycle environmental estimate. USAEC will coordinate closely with representatives from the program office, manufacturers and users to identify all environmental activities. Costs will be documented on a tailored work-breakdown structure and all costs will be further supported by individual cost-documentation formats.

Lessons learned from this and other projects will be used to develop an environmental cost handbook, which CEAC and the acquisition community can use to estimate life-cycle environmental costs. The handbook will include descriptions of environmental cost elements, cost estimating methodologies and recommended sources of cost information.

**ACCOMPLISHMENTS AND RESULTS**

This project is in the early stages. On October 19-20, 1998, USAEC staff attended a presentation and discussion of the program office estimate and independent cost estimate for SMART-T. USAEC is obtaining program reports and other documents for cost-analysis purposes. USAEC is also developing plans and schedules to complete the life-cycle cost analysis.

**POINT OF CONTACT**

James Heffinger

**PROGRAM PARTNERS**

U.S. Army Environmental Center
U.S. Army Cost and Economic Analysis Center
PM-Secure Mobile Anti-Jam Reliable Tactical Terminal

# ENVIRONMENTAL TECHNOLOGY PROGRAMS

P2&ETD technology development and transfer programs enable the Army to test and implement cost-effective technologies in cleanup, compliance, pollution prevention and conservation.

**Cleanup**
Many Army sites hold remnants from past training, testing and industrial operations. P2&ETD supports Army efforts to clean up these areas by providing cost-effective technologies to remove pollutants from soil, surface water and groundwater.

**Compliance**
Army installations must comply with laws and regulations governing wastewater discharge, noise abatement, air quality, and management of solid and hazardous waste. P2&ETD initiatives help the Army stay ready to meet constant changes in environmental laws.

**Pollution Prevention**
P2&ETD demonstrates and transfers cost-effective industrial process changes and technologies designed to help installations prevent pollution, use fewer hazardous materials and generate less hazardous waste.

**Conservation**
The Army manages 12 million public acres, which include a variety of natural and cultural resources. P2&ETD supports Army efforts to protect these irreplaceable resources while providing realistic backdrops for military training.

## BIOVENTING OF POL-CONTAMINATED SOILS

Many operational facilities contain soil contaminated with petroleum, oils and lubricants (POLs). Excavation of this soil for remediation can disrupt Army operations. Bioventing offers an alternative to excavation and incineration by relying on existing microorganisms to remediate the waste.

**PURPOSE**

To transfer bioventing technology from the Air Force for use in remediating POL-contaminated sites on Army installations.

**TECHNOLOGY USERS**

Army installations.

**DESCRIPTION**

Many Army sites contain POL contamination. These sites include aircraft areas, maintenance areas, leaking storage tanks, burn pits, chemical disposal areas, disposal wells and leach fields, landfills and burial pits, fire-fighting training areas and surface impoundments.

POL contamination in the unsaturated (vadose) zone exists in four phases: vapor in the pore spaces; sorbed to subsurface solids; dissolved in water; or as non-aqueous phase liquid (NAPL). The nature and extent of transport are determined by the interaction among contaminant transport properties (e.g., density, vapor pressure, viscosity and hydrophobicity) and the subsurface environment (e.g., geology, aquifer mineralogy and groundwater hydrology).

Common treatment technologies for POLs in soil include excavation and landfilling, biodegradation, incineration, soil vapor extraction (SVE) and low-temperature thermal desorption. Implementing in-situ remediation techniques would greatly reduce cleanup costs for POL-contaminated sites.

The Air Force Center for Environmental Excellence (AFCEE) developed bioventing, which is the process of

providing naturally occurring soil microorganisms with oxygen to promote in-situ degradation of POLs. The basic elements of a bioventing system include a well – or series of wells – and a blower system that pumps air through the well and into the ground.

This technology transfer effort consists of treatability studies and pilot-scale demonstrations at various sites. Testing bioventing under real scenarios will build confidence in the technology and increase awareness among Army users.

Based on AFCEE and commercial applications, costs for operating a bioventing system range from \$10 to \$60 per cubic yard. The time required to clean up a site ranges from one to five years to remove benzene, toluene, ethylbenzene and xylene (BTEX) constituents and two to 10 years to remove total petroleum hydrocarbons (TPH). Many factors can affect cost and duration, including contaminant type and concentration, soil permeability, spacing and number of wells, pumping rate, and off-gas treatment. For these reasons, initial treatability studies must be performed to determine bioventing's effectiveness at each site.

Bioventing does not require expensive equipment and systems can be left unattended for long periods. Typically, only periodic maintenance and monitoring is conducted.

## Accomplishments and Results

In May 1997, the pilot system at Fort Carson, Colorado, was scaled up to provide full-scale remediation. Yearly testing in May 1998 indicated that contaminant levels had been reduced below state action levels. Consent is being sought from the state to close the site.

The pilot system at Fort Rucker, Alabama, should provide full-scale cleanup. Yearly testing in September 1998 found that BTEX compounds had been reduced to nondetectable levels and TPH had been greatly reduced in the treatment area. Consent will be sought from the state to pursue site closure.

## Limitations

In May 1997, annual testing of the pilot system at Fort Bliss, Texas, indicated that biological activity had decreased while contaminant levels remained elevated. This phenomenon has occurred at several of the Southwestern desert sites where

bioventing systems have operated for extended periods. The decrease in biological activity may be due to a variety of factors, such as low soil moisture or lack of nutrients.

### Follow-On Program Requirements

Document the study results on the U.S. Army Environmental Center Web site and in various publications to promote the use of bioventing within the Army.

### Points of Contact

Gene Fabian
Tanya Lynch

### Program Partners

U.S. Army Environmental Center
Fort Bliss, Texas
Fort Rucker, Alabama
Fort Carson, Colorado

## C-Sparge Treatment System at Letterkenny Army Depot

The C-Sparge treatment system promises to be an effective way to remove volatile compounds from water. Installation of this system at the Rowe Spring site at Letterkenny Army Depot, Pennsylvania, will help remove contamination and treat a water supply for livestock.

**Purpose**

To prepare and implement a final design of the C-Sparge treatment system for the Rowe Spring site at Letterkenny Army Depot, an installation on the National Priorities List.

**Benefits**

If installed successfully, this system will help remove volatile organic compound (VOC) contamination, protect the surrounding environment and provide a treated water supply for livestock.

**Technology Users**

Letterkenny Army Depot.

**Description**

The U.S. Army Environmental Center (USAEC) awarded a contract to conduct bench-scale and pilot tests of the system, complete the design and construct the treatment system. Effluent testing will begin after system construction. A basic C-Sparge treatment system uses a fine-bubble diffuser to facilitate the removal of contaminants from the affected media.

**Accomplishments and Results**

USAEC awarded a contract for design and installation of the Rowe Spring treatment system. Letterkenny Army Depot applied for site permits.

**Follow-On Program Requirements**

- Conduct C-Sparge system pilot test.
- Issue draft version of the final design.
- Complete system construction.
- Start treatment system and initiate effluent testing.

**Point of Contact**

Scott Hill

## Design Guidance Manual for a Disposable Hot Gas Decontamination System

Hot Gas Decontamination (HGD) is a proven technology for treating chemical- and explosives-contaminated facilities and equipment, but it is expensive to implement and operate over long periods. Most sites could operate an HGD system for less than a year and still get acceptable results. This manual will help installations design and implement a system for short-term operations.

### Purpose

To prepare a guidance manual that helps installation personnel determine the applicability of HGD technology and prepare a design that uses locally available stock items, standard equipment, simple controls, and rented or leased equipment based on a single use and short project life.

### Benefits

HGD technology allows the decontamination of facilities and equipment so they may be reused, disposed of as scrap, or disposed of as solid waste.

### Technology Users

Department of Defense installations with explosives-contaminated facilities and equipment.

### Description

HGD technology has been demonstrated at four installations and is used at Hawthorne Army Depot, Nevada, in a fixed facility. The technology uses a gas-fired or oil-fired burner to produce heat, which is ducted into an insulated treatment area. The treatment area is fitted with thermocouples to determine when the treatment temperature has been reached. Three to six hours is usually enough time to treat masonry and metals once the treatment temperature is reached. The time from "heat up" to cool down is usually 24 to 72 hours, depending on the thickness of the materials.

This task was conducted to identify the cheapest construction materials, the lowest-priced and simplest controls, and the cheapest means of insulating the area to be decontaminated. The intent is to create an HGD system an installation can use once and throw away.

The Army's Industrial Operations Command, in IOC Pamphlet 385-1, qualified the HGD process as capable of achieving the 5X level of decontamination.

**ACCOMPLISHMENTS AND RESULTS**

A design guidance manual has been produced for a low-cost disposable system.

**POINT OF CONTACT**

Wayne Sisk

**PROGRAM PARTNERS**

U.S. Army Environmental Center
Parsons Engineering Science, Inc.
Pacific Northwest National Laboratories
Battelle Columbus Operations

**PUBLICATIONS**

*Low-Cost Disposable Hot Gas Decontamination System for Explosive-Contaminated Equipment and Facilities.* SFIM-AEC-ET-CR-98046. November 1998.

## Evaluating Natural Attenuation at Industrial Operations Command Sites

Numerous Army Industrial Operations Command (IOC) installations contain sites where past production, testing and training activities left contamination in the soil and groundwater. In this project, natural attenuation will be evaluated as a potential cleanup remedy at IOC sites contaminated with petroleum hydrocarbons, solvents or metals.

**Purpose**

To evaluate the feasibility of implementing natural attenuation as a potential cleanup remedy at sites contaminated with petroleum hydrocarbons, solvents or metals.

**Benefits**

Contaminated sites across IOC will be evaluated for application of natural attenuation using a standard methodology. This will enhance the success of employing natural attenuation as an alternative to more costly, engineered remediation options.

**Technology Users**

Department of Defense installations.

**Description**

A standardized methodology was developed to consider the feasibility of applying natural attenuation as a cleanup option, and provide decision-makers with a quantitative "bottom line" to judge the success of employing natural attenuation.

A query of the Army's Defense Site Environmental Restoration Tracking System (DSERTS) database identified more than 200 IOC sites with petroleum, solvent or metals contamination. This list was trimmed to 99 sites by eliminating sites that indicated mixed contamination with inorganics, explosives, pesticides or herbicides. Cleanup priority and cost information gathered from Installation Action Plans and the policies of state regulatory agencies on natural attenuation were then used to narrow the list to the top 20 sites where natural attenuation was most feasible.

The next step involved gathering data on the extent and magnitude of contamination; the geologic and hydrogeologic formation; the location of the contamination sources; and the distances to potential receptors for each of these 20 sites. This information was used to compare the rate of contaminant transport to the rate of physical and biological attenuation using BIOSCREEN, an analytical solute transport model developed by the Air Force Center for Environmental Excellence for screening natural attenuation candidate sites. The study then described the top sites in order of priority, and identified gaps in data required to complete full-scale natural attenuation modeling.

Finally, the cost of pursuing natural attenuation for the top 10 of these sites was evaluated. This included the cost of gathering the data necessary to conduct comprehensive natural attenuation transport modeling, and the expense of site monitoring for up to 30 years. A final matrix was prepared to present the pros and cons of the selected sites, provide additional data for completing full-scale risk-based natural attenuation modeling, and compare the cost of natural attenuation to engineered remediation.

**POINT OF CONTACT**

Mark Hampton

**PROGRAM PARTNERS**

U.S. Army Environmental Center
U.S. Army Industrial Operations Command
U.S. Army Tank-automotive and Armaments Command
Platinum International, Inc.

**PUBLICATIONS**

A report will be available at the conclusion of the project (3rd quarter FY 1999).

The major source of error associated with an analytical result is derived from sampling, yet little has been done to improve the process. A cost-effective method to accurately determine the distribution of contaminants will benefit Army site-remediation efforts.

**PURPOSE**

To create a procedure whereby the error associated with collecting soil samples can be applied correctly to the analytical results; to develop a strategy and procedure for the determination of explosives contamination at impact ranges, and adapt it to other analytes when appropriate.

**BENEFITS**

A cost-effective method to determine the distribution of contaminants will benefit the site-remediation process. Because they contain unexploded ordnance (UXO), impact ranges present a unique cleanup challenge. Some Records of Decision require the Army to deal with explosives before addressing UXO. The developed strategy will allow installations to handle this scenario.

**TECHNOLOGY USERS**

Army installations with explosives-contaminated soils.

**DESCRIPTION**

The major source of error associated with an analytical result is derived from sampling, but little has been done to improve the process. Previous sampling was based on a specified grid approach, which resulted in extreme sampling error for nonhomogenous distributed contaminants such as explosives. True and cost-effective determination of the distribution of contaminants is essential to the site remediation process.

A site contaminated with HMX and TNT will be assessed. A final report will document the sampling and analytical errors associated with short-range and longer-range analyte distributions for this site. The report also will document improvements in site characterization that result from the use of a composite-based sampling procedure and on-site analysis, and address whether this approach reduced sampling error to acceptable levels for this site.

Additional sampling and analysis studies will be conducted to demonstrate the effectiveness of the combination of on-site analytical methods and simple composite sampling procedures. Sites contaminated with RDX and NG will be sampled (if available), as well as a non-explosives-contaminated site, to assess whether levels of heterogeneity at these sites are similar to those observed for sites contaminated with TNT, DNT, ammonium picrate and HMX. An evaluation will be performed between field analytical results and laboratory analytical results.

## Accomplishments and Results

In Phase 1 of this project, several explosives-contaminated sites were intensely sampled to obtain information on the short-range heterogeneity of analyte distribution as a function of the specific contaminant, mode of contamination and soil type. The samples were analyzed both on and off site.

These results were used to compute overall analytical error. The on-site analytical methods for TNT, DNT and picric acid provided adequate data for site assessment at much lower costs. Based on these results, various strategies to minimize sampling error were considered and a larger-scale sampling strategy proposed.

This approach was evaluated in Phase 2 at a site contaminated with HMX and TNT. Analysis of larger-scale sampling and analytical results indicated that an approach based on discrete grab sample collection and analysis could not adequately describe analyte concentrations. A rapid compositing approach was assessed and the analysis of these results showed this was the best approach for sampling nonhomogenous distributed contamination. This approach was further validated at a site contaminated with RDX and TNT. It also underwent preliminary testing at an impact range.

In the next phase, a pilot study on applying the sampling strategy learned from the previous effort was performed at an inland impact range at Fort Ord, California. Because of the UXO issue, the strategy was modified to include actual sampling being performed by Explosive Ordnance Disposal (EOD) personnel. Sampling was also modified to address the effects of long-range heterogeneity. Experiments were

conducted to assess the utility of a Gas Chromatograph-Nitrogen/Phosphorous Detector method for on-site analysis of explosives in soil. Results were promising in that they allowed measurement of RDX in the presence of large amounts of HMX, a contaminant situation often encountered at anti-tank firing ranges.

**Follow-On Program Requirements**

A strategy based on the previous experiences will be developed to sample impact ranges and perform appropriate analyses. Site(s) will be selected to demonstrate the strategy. The strategy will be revised, when necessary, based on earlier demonstrations. Revised procedures will be demonstrated at additional sites to factor in differences between sites and contaminants. Ruggedness and universality of the application will be demonstrated. Procedures will be developed to guide the application to the "different" site. Results will be provided in final reports.

**Point of Contact**

Martin Stutz

**Program Partners**

U.S. Army Environmental Center
U.S. Army Engineer Research and Development Center-Cold Regions Research and Engineering Laboratory

**Publications**

*Assessment of Sampling Error Associated with Collection and Analysis of Soil Samples at Explosives-Contaminated Sites*. CRREL Special Report 96-15.

EPA ORD/OSWER. *Field Sampling and Selecting On-Site Analytical Methods for Explosives in Soil – EPA Federal Facilities Forum Issue*. Report EPA/540/R97/501. November 1996.

*Assessment of Sampling Error Associated with Collection and Analysis of Soil Samples at a Firing Range Contaminated with HMX*. CRREL Special Report 97-22.

*Site Characterization of the Inland Firing Range Impact Area at Fort Ord*. CRREL Special Report 98-9.

## Fielding Biotreatment Technologies Under the Agriculture-Based Bioremediation Program

The Agriculture-Based Bioremediation Program is a congressionally sponsored partnership between the Army and the U.S. Department of Agriculture to demonstrate agronomic remediation processes to restore contaminated military and civilian sites – with emphasis on sites the Pacific region.

**Purpose**

To demonstrate agronomic remediation processes to restore contaminated military and civilian sites, emphasizing sites in fragile Pacific island ecosystems.

**Benefits**

Besides proving out dual-use agriculturally based technologies, the program actively supports capability building and education, and provides economic opportunities and environmental security to island communities.

**Technology Users**

Department of Defense installations.

**Description**

A variety of field demonstrations are being conducted under the Agriculture-Based Bioremediation Program (ABRP).

Green waste composting was demonstrated in 1998 at Schofield Barracks, Hawaii. This project evaluated the performance and cost of alternative composting methods for reducing green waste to useful horticulture products. Both aerated static pile and commercial in-vessel aerated static pile processes produced quality, finished compost in 55 days. The Army's cost/benefit analysis anticipates the economic return on green waste composting will pay for the process within two years of operation, while reducing the installation's nonhazardous waste stream.

The U.S. Army Corps of Engineers is performing pilot-scale tests of multiple methods of composting green waste and sewage sludge from the Schofield Barracks wastewater treatment plant. The performance and cost of aerated static pile and windrow composting will be compared to a commercial in-vessel aerated static pile process, with results due in late spring 1999. The potential cost avoidance is

significant, since Schofield Barracks alone pays $10,000 a month to dispose of its sewage sludge and about $130,000 a month in tipping fees for green-waste disposal.

Del Monte Fresh Produce Inc. is conducting a field demonstration of phytoremediation to treat groundwater contaminated with volatile organic compounds, including ethylene dibromide, 1,2 dibromo-3-chloropropane and 1,2 dichloropropane. Pilot-scale tests have shown the *Luecaena leucophala* (or Koa Haole) plant can effectively remove the contaminants for half the cost of carbon treatment. After test results permit authorities to assess the long-term effectiveness of the process, the phytotreatment units can be scaled up to remediate a site on the Environmental Protection Agency's National Priorities List.

The Dole Food Company, in partnership with the Navy in Hawaii, will field-test a 1.3-acre phytotreatment wetland to biotreat municipal wastewater for use in above-ground irrigation. Recovery of wastewater has important commercial and municipal applications across the islands, where fresh water can be at a premium.

## Results and Accomplishments

A Broad Agency Announcement (BAA) was initiated in October 1998 to open the program to more government, commercial and academic participants. The BAA is available at www.mvk.usace.army.mil/contract (select "Procurement Opportunities" then "Broad Agency Announcements").

## Follow-On Program Requirements

- Monitor the progress of ongoing ABRP demonstrations.
- Facilitate technology transfer.
- Start new projects through the BAA.

## Point of Contact

Mark Hampton

## Program Partners

U.S. Army Environmental Center
U.S. Department of Agriculture
U.S. Army Engineer Research and Development Center-Construction Engineering Research Laboratories

U.S. Army Engineer Research and Development Center-
Waterways Experiment Station
Tennessee Valley Authority

**PUBLICATIONS**

U.S. Army, Pacific *Pilot Compost Facility, U.S. Army Garrison, Hawaii, Schofield Barracks, Final Report.* May 1998.

Other reports will become available as individual projects are completed.

## Groundwater Extraction and Treatment Effectiveness Reviews

The U.S. Army spends millions of dollars each year to operate and maintain major groundwater pump-and-treat systems, but most of the systems have no defined measures of effectiveness. The Groundwater Extraction and Treatment Effectiveness Reviews will help installations determine how well a system is performing, when the system has reached the end of its usefulness, or whether another method could meet remediation goals at lower costs.

**Purpose**

To institute an Armywide program for developing clear remediation objectives and measures of effectiveness for planned and installed groundwater pump-and-treat systems. For systems where remedial objectives cannot yet be obtained, the program will reevaluate and renegotiate the objectives using risk-based approaches and reasonable land-use scenarios.

**Benefits**

Optimization of existing systems and the proper setting of objectives could help the Army potentially avoid costs of $100 million in the next 10 years.

**Technology Users**

Major Army commands and installations with operating or proposed pump-and-treat systems.

**Description**

The U.S. Army operates major groundwater pump-and-treat systems at 35 installations, with a yearly operations and maintenance cost of approximately $25 million. Each major system costs about $3 million to build and is expected to last at least 30 years. Of the systems with a definable objective, more than half were designed to contain plumes, not restore aquifers. Most of the systems have no defined measures of effectiveness; the Army therefore has little or no ability to determine how well a system is performing or when a system has reached the end of its usefulness. In addition, approximately 70 major pump-and-treat systems are in the planning stages within the Installation Restoration, Base Realignment and Closure (BRAC) and Formerly Used Defense Sites (FUDS) programs.

An Army Science Board study on the effectiveness of groundwater and soil treatments recommended that a team of independent experts review the Army's largest groundwater pump-and-treat remediation programs (according to cost-to-complete estimates). The study also recommended implementing a groundwater cleanup strategy to reduce the number of pump-and-treat systems being proposed in the Army's environmental program.

The Groundwater Extraction and Treatment Effectiveness Reviews will:

- Validate the objectives of remediation systems;
- Determine measures of effectiveness;
- Collect the data necessary to measure system effectiveness;
- Examine the remediation objectives and compare these goals to appropriate human and ecological risk levels for the current and future site use;
- Create a process for acquiring the resources to implement system modification and/or replacement where significant long-term cost savings are identified;
- Provide "lessons learned" to the field and Army Headquarters;
- Produce cost savings of 10% to 20% and make systems more cost-effective.

An effectiveness review team is made up of individuals experienced in the design, operation and optimization of pump-and-treat systems, as well as in the regulatory aspects of Record of Decision (ROD) development and modification. Depending on the installation's technical and regulatory situations, the team uses different mixes of in-house and outside experts. The disciplines that might be required include:

- Groundwater modeling and hydraulic optimization;
- Hydrogeology;
- Environmental law and ROD development;
- Process and chemical engineering;
- Innovative technology;
- Risk assessment;
- Natural attenuation processes;
- Community relations.

A contractor handles the team's administrative requirements, such as data collection, preparing the site for the visit and

preparing reports. Team members could be drawn from the U.S. Army Environmental Center, the Army Center for Health Promotion and Preventive Medicine, the Groundwater Modeling Support Program at the U.S. Army Engineer Research and Development Center-Waterways Experiment Station, the U.S. Army Corps of Engineers Hazardous, Toxic, and Radioactive Waste Center of Expertise, the Department of Geography and Environmental Engineering at the U.S. Military Academy, the U.S. Geological Survey, Environmental Protection Agency laboratories, the Department of Energy and nongovernment entities. Local regulatory agencies and community representatives may be involved in the later stages of a site visit.

**ACCOMPLISHMENTS AND RESULTS**

A team examined a proposed pump-and-treat system at Hunter Army Airfield in Savannah, Georgia. The system was proposed to contain a petroleum plume (mainly benzene) emanating from a former underground storage tank site near a runway. The team recommended ways to handle the problem without constructing a pump-and-treat system. The recommendations were well received by the installation and the U.S. Army Corps of Engineers' Savannah District.

Based on the team's visit, the proposal for a $1.8 million (capital cost) system is on hold. The team's recommendation for approximately $100,000 worth of sampling and analysis during the next year will lead to the selection of a monitored natural attenuation remedy. Use of monitored natural attenuation instead of the proposed pump-and-treat and soil vapor extraction system will save approximately $5 million over the life of the project

**LIMITATIONS**

Reviews are labor intensive and only a few can be accomplished each year.

**POINT OF CONTACT**

Ira May

**PROGRAM PARTNERS**

U.S. Army Environmental Center
Major Army commands
Installations with operating or proposed pump-and-treat systems

**PUBLICATIONS**

*Evaluation of the Effectiveness of Existing Groundwater and Soil Treatments*. Army Science Board. 1998.

## GROUNDWATER MODELING SYSTEM AND SUPPORT CENTER

When it comes to groundwater treatment, state-of-the-art tools and techniques can save installations vast amounts of money. The Groundwater Modeling System and Support Center provides technical expertise to installations and other users of groundwater modeling technologies.

**PURPOSE**

To provide groundwater modeling technical expertise to installations and other users of groundwater modeling technologies.

**BENEFITS**

State-of-the-art modeling can save vast amounts of money, as can a system to help ensure that proper remedial actions are carried out.

**TECHNOLOGY USERS**

Army installations and U.S. Army Corps of Engineers districts.

**DESCRIPTION**

The Groundwater Modeling Technical Support Program, sustained jointly by the U.S. Army Environmental Center (USAEC) and the U.S. Army Corps of Engineers Military Programs Office (CE-MP), has been assisting agencies and Army installations for several years. The program is administered by the Groundwater Modeling Technical Support Center at the U.S. Army Engineer Research and Development Center-Waterways Experiment Station (WES) and is overseen by a technical advisory group from the funding agencies. The program has provided technical expertise and products to a rapidly expanding group of users, evidenced by 1,894 successfully answered support calls over the last three years. The technical expertise made available through the program has led to more efficient remediation projects.

Many of the calls have come from Army installations looking for Department of Defense Groundwater Modeling System (GMS) support. The GMS was developed specifically to address groundwater remediation projects in the U.S. Army. Although USAEC has been the largest supporter of the system, other agencies, including the Environmental Protection Agency (EPA) and the Department of Energy (DOE), have recently followed the Army lead by supporting GMS technology.

Consequently, several federal and local government agencies have accepted GMS as their standard modeling system for addressing groundwater remediation. The GMS has 622 users in the United States and is accepted by the EPA's Superfund and Wellhead Protection programs. The EPA also uses GMS in all 10 of its regional offices.

The rapid increase in technical support requests demonstrates widespread acceptance of GMS technology. The acceptance is largely based on the system's advanced technology, and because government institutions such as USAEC, CE-MP, WES and the EPA have led its development. Equally significant are the high quality-control standards and technical support programs that ensure the maintenance and improvements necessary for software longevity – an important consideration for installations where cleanup actions can take many years.

## Accomplishments and Results

- Continued providing groundwater modeling technology transfer assistance to Army users. This support included the distribution of the GMS software and manuals, and providing training as needed.
- Provided telephone support and on-site technical assistance, as necessary, to installations conducting groundwater remediation activities. Site assistance was typically limited to less than one man-week of labor (per site) and travel costs.
- Demonstrated the utility of optimization in reducing the inherent costs of pump-and-treat remediation systems.
- Demonstrated the capability and cost-effectiveness of natural attenuation modeling in reducing remediation costs. This was accomplished by reducing the number of years required for active remediation systems such as pump-and-treat.
- Distributed results from the demonstration projects to installation personnel to ensure technology transfer within the Army.

## Limitations

Due to resource limitations, not all installations have been able to receive assistance from the center.

**FOLLOW-ON PROGRAM REQUIREMENTS**

The institutional support provided by USAEC is necessary for the continued success of the program.

**POINT OF CONTACT**

Ira May

**PROGRAM PARTNERS**

U.S. Army Environmental Center
U.S. Army Engineer Research and Development Center-Waterways Experiment Station
U.S. Army Engineer Research and Development Center-Cold Regions Research and Engineering Laboratory
Headquarters, U.S. Army Corps of Engineers

**PUBLICATIONS**

*Groundwater Modeling System, Version 2.1.*

## IN-SITU ELECTROKINETIC REMEDIATION FOR METALS-CONTAMINATED SOILS

Remediating heavy metals in environmentally sensitive areas presents a challenge to the Department of Defense. Often, these sites are used as wildlife habitats and public recreation areas. Technologies such as electrokinetic remediation allow for nonintrusive remediation.

**PURPOSE**

To demonstrate the use of electrokinetics for in-situ extraction of heavy metals from soil.

**BENEFITS**

Electrokinetic remediation is potentially less invasive in ecologically sensitive areas and more cost-effective than other metals-removal technologies.

**TECHNOLOGY USERS**

Military installations with metals-contaminated soils.

**DESCRIPTION**

Military activities are primary contributors to metals contamination in soil. Military operations, such as small arms training, electroplating and metal finishing, explosives and propellant manufacturing and use, and use of lead-based paint have resulted in vast areas of contaminated land. This creates a need for cost-effective remediation tools. Current technologies include excavation and solidification/stabilization methods, followed by landfilling of the contaminated soils. These methods are expensive and may only provide a temporary solution. A low-cost method of extracting contaminants from soil without excavation is needed to effectively address this problem. Electrokinetics has been identified as a possible method of performing in-situ extraction of metals from soil.

Heavy metals are an environmental problem, especially in an aqueous environment. Because mobile metal ions are charged particles, it is possible to use an electric current to move those particles.

The electrokinetic process is an in-situ continuous process that can be used to remove or capture heavy metals, radionuclides, and selected organic pollutants from sands, silts, fine-grained clays and sediments.

Electrokinetics involves the use of electrodes arranged in cathode and anode arrays. The electrodes are positioned inside permeable, water-filled casings inserted into the soil. Energizing the electrodes initiates hydrated ionic movement through the soil and groundwater toward the electrodes. Through electromigration and electro-osmosis, the contaminants are transported through the soil for recovery at the cathode. The contaminant metals can either electroplate on the electrodes in the wells, or concentrate in the well electrolyte for removal.

The site selected for the full-scale electrokinetic soil remediation demonstration is at Point Mugu Naval Air Weapons Station (NAWS) in Ventura County, California. The installation is located about 50 miles northwest of Los Angeles and comprises approximately 4,500 acres. Point Mugu NAWS is situated in the western portion of the Ventura Basin, with the Santa Monica Mountains directly to the east.

The demonstration area is known as Site 5, a large area where many industrial and military operations were conducted. The specific area of study is approximately 1/2 acre in and around two waste lagoons in the center of Site 5. These unlined lagoons were used between 1948 and 1978 to receive wastewater discharge, which included up to 60,000 gallons of photovoltaic fixer, small quantities of organic solvents, rocket fuel, and approximately 95 million gallons of plating rinse water. The waste lagoons, located in a tidal marsh area, measure approximately 30 feet by 90 feet and range in depth from 4 feet to 5 1/2 feet. They are surrounded by an elevated berm approximately 2 feet above the water level. The waste lagoons typically contain standing water, which fluctuates with the tides. The area around the pits is bounded by Beach Road on the south side and the tidal marsh on the remaining three sides.

An emergency action in 1994 removed approximately 117 cubic yards of material to limit exposure to resident and migratory birds and reduce the potential source of contamination for surface and groundwater. This area is inhabited by the light-footed clapper rail, a federally and state-listed endangered species, as well as other species. Before the emergency removal, the levels of chromium, cadmium, copper, nickel and silver were high. After the emergency action, surface sampling in the lagoons indicated

that cadmium and chromium levels still exceeded Total Threshold Limit Concentrations described in the California Code of Regulations (Title 22, Section 66261.24). Further excavation is not desired because of the site's ecological sensitivity. Other potential chemical contaminants of concern at the site include arsenic, beryllium, Aroclor-1260, tetrachloroethane, trichloroethene, manganese and fluoride. Activities are restricted by the presence of endangered species.

## Accomplishments and Results

After approximately three months of operation (ending in May 1998), the field and lab study data was reviewed. The field data indicated the electrokinetic process had no effect in test cell No. 1 (the treatment zone within the waste lagoon area). No pH effect or mobilized metal ions were detected in the breakout monitoring piezometer wells located in the treatment zone. Process control monitoring, which consisted of electrolyte sampling in the anode and cathode wells, and piezometer well and soil sampling in a defined process control zone, also provided no indication of pH front development or mobilized metal ions.

The process control zone is an area between two electrodes where well and soil samples were collected at varying distances to monitor process development. Although pH suppression was achieved in the electrode wells and an electric field had been established in the treatment zone between the electrode arrays as expected, no treatment had occurred. The review of U.S. Army Engineer Research and Development Center-Waterways Experiment Station (WES) lab results from recently completed analyses of 5-foot and 10-foot test cells conflicted with data collected from earlier WES treatability studies conducted in 10-centimeter test cells using Point Mugu soil. No significant metal migration was detected in the 5-foot and 10-foot test cells after seven months of operation. Significant metals migration had been detected in the 10-centimeter test cells, which had operated for two months.

The differing results had not been observed in earlier laboratory, bench- and pilot-scale field tests conducted at other sites. Laboratory tests conducted by the electrokinetics

contractor showed excellent metal movement and extraction over a six-month period. However, these lab results had little correlation with the field tests. The operation of the lab test cells were not representative of the design and operation of the system in the field. The lab tests were operated with uncontrolled electro-osmotic flow; continuous pH controlled acid addition; constant amperage (as opposed to constant voltage in the field); a current density 23 times higher than that initially applied in the field; lower soil pH than planned for field implementation; and a different well design than that implemented in the field. A detailed review of the data and cause-and-effect analyses are in progress.

**LIMITATIONS**

Observations of the technology indicate numerous factors may inhibit its performance. These factors may include (but are not limited to) competing with noncontaminant ions (for mobilization), heterogeneity in the permeability of the soil within the treatment zone, and soil organic content.

**FOLLOW-ON PROGRAM REQUIREMENTS**

Further investigation into the identification and understanding of the in-situ factors that retard the performance of the technology. Once identified, methods to overcome the inhibiting effects of these factors must be developed.

**POINT OF CONTACT**

Gene Fabian

**PROGRAM PARTNERS**

U.S. Army Environmental Center
Point Mugu Naval Air Weapons Station, California
U.S. Army Engineer Research and Development Center-Waterways Experiment Station
Environmental Security Technology Certification Program

## ◀ Intrinsic Remediation Study of POL-Contaminated Sites

Many operational facilities have groundwater contaminated with petroleum, oils and lubricants (POLs). Remediation options include excavation and pump-and-treat operations that are expensive and can disrupt Army operations. Intrinsic remediation allows for the least-expensive cleanup of contaminated groundwater with no impact on current operations.

**Purpose**

To transfer intrinsic remediation technology from the Air Force for use in remediating POL-contaminated sites on Army installations.

**Benefits**

Intrinsic remediation has widespread potential application because native organisms can degrade a variety of petroleum products, including jet fuel, gasoline, diesel fuel and heating oils. In-situ treatment of fuel contaminants in groundwater greatly reduces the expense and inconvenience associated with traditional pump-and-treat methods. Intrinsic remediation also eliminates the need for expensive off-gas treatment often required with in-situ air sparging. It produces harmless byproducts and does not interfere with ongoing site operations. There is no equipment to maintain and it can be applied to inaccessible areas. Intrinsic remediation is supported by the American Society for Testing and Materials (ASTM) Guide for Risk- Based Corrective Action (RBCA).

**Technology Users**

Army installations.

**Description**

Intrinsic remediation is the reduction of contaminant concentration in the environment through existing biological processes (aerobic and anaerobic biodegradation), physical phenomena (advection, dispersion, dilution, diffusion, volatilization, sorption/desorption) and chemical reactions (ion exchange, complexation, abiotic transformation). Geologic, hydrogeologic, chemical and biological site information is used to model the contaminant degradation rates and pathways.

During intrinsic remediation, the contamination plume undergoes aerobic (oxygen) bioremediation followed by

anaerobic (nitrate, iron, sulfate and methane) bioremediation by indigenous microbes. No added cultures or nonnative organisms are used. No external means are employed to speed up remediation; the process is completely governed by natural means. Intrinsic remediation is accepted as a remedial alternative in 37 states and in all 10 Environmental Protection Agency regions.

## Accomplishments and Results

In September 1998, field sampling to collect data for the intrinsic remediation model was conducted at a contaminated groundwater site at Fort Jackson, South Carolina. Samples are being analyzed for input to the model.

## Limitations

- High contaminant concentrations (total petroleum hydrocarbon levels greater than 25,000 parts per million may necessitate source removal).
- Potential impact to human and ecological receptors.
- State regulatory reluctance.
- Insufficient microbial activity.
- Lack of geologic and hydrogeologic homogeneity (which results in inaccurate contaminant mobility modeling).
- Long remediation periods.

## Follow-On Program Requirements

- Finalize the treatability study in support of remediation by natural attenuation with long-term monitoring.
- Use the report results to provide technical support for natural attenuation with long-term monitoring as a remedial option during regulatory negotiations, as appropriate.

## Points of Contact

Gene Fabian
Tanya Lynch

## Program Partners

U.S. Army Environmental Center
Fort Jackson, South Carolina

## Optimization of In-Situ Volatilization Devices

Many Army installations use soil vapor extraction to remove volatile compounds from soil, mainly because they can leave the soil in place during the cleanup operation and save money. This project is developing a model that installations can use to improve the design and operations of such in-situ remediation systems.

**Purpose**

To develop a three-dimensional vadose zone model to assist in the optimization of in-situ volatilization systems.

**Benefits**

This model will be useful at both the design stage (to determine optimal vent spacing, depths and flow rates) and the operational phase (to determine optimal time of system operation and to balance the systems) of in-situ volatilization systems.

**Technology Users**

Installations with operating or proposed in-situ volatilization systems.

**Description**

Many Army sites have subsurface contamination problems stemming from disposal of volatile organic compounds (VOCs). Soil vapor extraction (SVE) has often been used to remediate the unsaturated zone, mainly because it leaves the soils in place during the cleanup process and results in large cost savings. Field implementation of SVE systems has often proceeded without the benefit of numerical modeling to provide an optimum engineering design and estimate the time required for cleanup.

The U.S. Army Environmental Center (USAEC) is conducting characterization and cleanup activities at Twin Cities Army Ammunition Plant (TCAAP), Minnesota, to remediate contaminated soils, sediments and groundwater. These remediation efforts include SVE systems at two sites to remove VOCs from soils and reduce contaminant migration to groundwater. The SVE systems have operated since 1987 and, according to sampling data, have removed large volumes of VOCs. They provide a platform to calibrate a new vadose-zone model and test proposed optimization concepts.

The objective of this study was to use site-specific data collected at TCAAP to develop a multidimensional, unsaturated numerical model for analyzing the effectiveness of SVE. Once the model was calibrated and validated, it was used to assess the efficiency of the remediation systems, evaluate alternative designs, and determine possible improvements. As part of the study, sensitivity and importance analyses were conducted to identify the critical input parameters needed to simulate the SVE process. The results of this study will be used to bridge the gap between using empirical correlation and field experience for system design and using numerical modeling for evaluating system performance and design.

**ACCOMPLISHMENTS AND RESULTS**

A paper on preliminary study results was presented at the 1998 National Defense Industry Association (NDIA) meeting in Tampa, Florida.

**LIMITATIONS**

Not all sites will have the data necessary to take advantage of the proposed optimization concept.

**POINT OF CONTACT**

Ira May

**PROGRAM PARTNERS**

U.S. Army Environmental Center
Argonne National Laboratory
Twin Cities Army Ammunition Plant, Minnesota

**PUBLICATIONS**

May, I.P., Z. Jiang, and L.A. Durham. "Evaluation of the Soil Vapor Extraction System at the Twin Cities Army Ammunition Plant: A Post-Audit Assessment." NDIA presentation. April 1998.

## Phytoremediation of Explosives in Groundwater Using Constructed Wetlands

Many Department of Defense (DoD) sites contain explosives-contaminated groundwater. Demonstrating cost-effective methods to treat this contamination will allow installations to conduct restoration using reliable, accepted and effective processes. Phytoremediation, which is the use of plants and microbes to degrade explosives, provides an opportunity to treat large volumes of groundwater at lower costs.

### Purpose

To demonstrate the use of phytoremediation as an alternative technology.

### Benefits

Phytoremediation destroys organic contaminants in groundwater at lower costs; the savings can be applied to other installation operations or restoration efforts.

### Technology Users

Army and DoD installations with explosives-contaminated groundwater.

### Description

Current groundwater cleanup technologies, such as granular activated carbon (GAC) and advanced oxidation, are labor-intensive and costly. GAC requires additional disposal. Ultraviolet oxidation systems require significant capital investment, labor and utilities expenses for the life of the project.

An alternative such as phytoremediation can provide lower maintenance and capital costs. Typically, a GAC system costs $2 million to $8 million for construction and $1.5 million annually (for 30 years) per site. Cost-performance data indicates that for surface water discharge, a gravel-based wetland yields capital costs of $330,000 per acre and $6,000 an acre (per year) to operate and maintain. For a site treating 500,000 gallons per week, the potential cost savings are $2 million.

Milan Army Ammunition Plant (MAAP) in Milan, Tennessee, was the site of the field demonstration. Prior efforts by the Environmental Protection Agency (EPA) identified the plant enzyme nitroreductase as able to degrade TNT.

In the initial phase of the project, plants native to Tennessee that contain the enzyme were challenged with explosives-contaminated water from the site. The three submergent and three emergent species that best reduced TNT and RDX, along with parrotfeather, were selected for the second phase.

Two distinct systems were constructed in the second phase: lagoon and gravel-based. The lagoon system, consisting of two cells in a series, was planted with submergent species in 2 feet of groundwater. The groundwater was treated by the plants, naturally occurring microbes and sunlight. The gravel-based wetland contained emergent plant species in both cells. The first cell was operated anaerobically (to degrade RDX) and the second cell was aerobic. This aerobic cell was a reciprocating wetland. Reciprocation, which is the movement of water between cell compartments, further enhances water quality.

Phytoremediation can be used as a pretreatment for other technologies or as a final "polishing" technology.

## Accomplishments and Results

Both wetland systems operated from June 1996 to September 1997. The lagoon system was not effective in degrading RDX under the demonstration parameters. Initially, the lagoon system degraded TNT, but as plant growth suffered, photodegradation was a major factor in TNT degradation. The system, requiring more attention in coaxing submergent species to grow in the contaminated groundwater, did not rebound and was taken out of operation in September 1997.

The gravel bed system was more effective in degrading TNT and RDX. On average, the gravel bed system reduced explosives residues with 95% or greater efficiency. TNT contaminants were reduced to less than 2 parts per billion (ppb) and total explosives were reduced from 10,000 ppb to less than 50 ppb. From October 1997 to July 1998, the gravel bed system operated under parameters that would allow for the design of a 200 gallon-per-minute (gpm) facility at the installation. The design and cost analysis for such a facility are included in the final report.

This demonstration has shown an approximate 56% cost avoidance in using constructed wetlands over granular media filter (GMF)/GAC. Amortized over 30 years, wetlands yield \$1.82 per kgal of water, of which \$1.52 is for operation and

maintenance. GMF/GAC yields $3.97 per kgal, of which $3.39 is operation and maintenance.

**LIMITATIONS**

Cool weather, time constraints and space requirements may limit use of phytoremediation in constructed wetlands.

**FOLLOW-ON PROGRAM REQUIREMENTS**

The final report is being completed and reviewed by the Environmental Security Technology Certification Program (ESTCP). A cost-performance report will be published by the ESTCP. Technology transfer efforts must continue.

**POINT OF CONTACT**

Darlene F. Bader

**PROGRAM PARTNERS**

U.S. Army Environmental Center
Tennessee Valley Authority
U.S. Army Engineer Research and Development Center-Waterways Experiment Station

**PUBLICATIONS**

*Phytoremediation of Explosives-Contaminated Groundwater in Constructed Wetlands: II- Flow Through Study.* SFIM-AEC-ET-CR-96167.

*Phytoremediation of Explosives-Contaminated Groundwater in Constructed Wetlands: I-Batch Study.* USAEC Report SFIM-AEC-ET-CR-96166.

*Demonstration Plan for Phytoremediation of Explosives-Contaminated Groundwater in Constructed Wetlands at Milan Army Ammunition Plant, Milan, Tennessee: Volume I and II.* SFIM-AEC-ET-CR-95090.

*Evaluation of Various Organic Fertilizer Substrates and Hydrolic Retention Times for Enhancing Anaerobic Degradation of Explosives-Contaminated Groundwater while Using Constructed Wetlands at the Milan Army Ammunition Plant, Milan, Tennessee.* SFIM-AEC-ET-CR-98031.

## ◀ Phytoremediation of Lead in Soil

Because it can leach into groundwater or surface water, lead in soil can jeopardize the continued operation of training ranges. Phytoremediation, which is the use of plants to remove or degrade contaminants from various environmental media, offers a reliable method for removing lead from soil.

### Purpose

To demonstrate the effectiveness of phytoremediation – specifically phytoextraction – in removing lead from soil.

### Benefits

Benefits from successful phytoremediation of lead-contaminated sites are lead removal from the soil and lead recovery for off-site disposal or potential recycling, which allows for nonrestrictive site use. Future costs of monitoring and maintaining a hazardous site or landfilled hazardous waste would be eliminated, as would the long-term liability associated with hazardous waste. Phytoremediation minimizes site disturbance and limits dispersal of contaminants, in contrast to excavating and landfilling soil.

Phytoremediation also costs much less than conventional methods. Phytoremediation of 1 acre to a depth of 50 centimeters is estimated to cost $60,000 to $100,000. Excavating and landfilling the same amount of soil is estimated to cost $400,000 to $1.7 million.

### Technology Users

Army and Department of Defense (DoD) installations with lead-contaminated soil.

### Description

Disposal and burning of scrap ammunition and powder, firing range use and similar activities have resulted in lead-contaminated soils at many DoD installations. Current treatments include excavation and landfilling, soil washing, or immobilization through chemical treatment. As a result, the metals are neither destroyed nor reclaimed. Liability, long-term monitoring and restricted land use all contribute to high costs.

Phytoremediation, specifically the technique of phytoextraction, is an alternative technology.

Phytoextraction is the use of plants to pull metals out of the soil solution and into the plant structure. Process optimization and treatability studies conducted by the Tennessee Valley Authority (TVA) have determined the most efficient plant species, leachate concerns, levels of soil amendments, amendment application, and fertilization effects on lead accumulation and extraction.

This project is demonstrating the use of phytoextraction at Twin Cities Army Ammunition Plant (TCAAP) in Arden Hills, Minnesota. TVA conducted optimization and treatability efforts before designing the field demonstration. Two 0.2-acre sites were selected for the demonstration. One site contained low concentrations of lead (740 parts per million [ppm]); the other had moderate lead concentrations (3,500 ppm). Two crops were planted on each site: corn in May 1998 and white mustard in August 1998. At the appropriate time in the growth cycle of each crop, soil amendments were applied to encourage uptake of lead. The crops were harvested and transported to a smelter. The demonstration will be repeated in 1999.

The U.S. Army Environmental Center (USAEC) and the Department of Defense Environmental Security Technology Certification Program have provided funding.

**ACCOMPLISHMENTS AND RESULTS**

Both crops were planted and harvested. Plant, soil and water samples were taken in accordance with the demonstration plan. All samples are being processed and analyzed. Preliminary data from the corn plant tissue indicates correlation with earlier greenhouse studies. An interim guidance document will be produced, based on the first year's data, and implemented during the second demonstration year to refine the methodology.

**LIMITATIONS**

Time constraints, as well as the depth and degree of contamination. Another limitation may be the length of the growing season and the availability of soil amendments in large quantities.

**POINT OF CONTACT**

Darlene F. Bader

**PROGRAM PARTNERS**

U.S. Army Environmental Center
Twin Cities Army Ammunition Plant, Minnesota
Tennessee Valley Authority
Alliant TechSystems

**PUBLICATIONS**

*Technology Demonstration Plan for Phytoremediation of Lead-Contaminated Soil at the Twin Cities Army Ammunition Plant, Arden Hills, MN.* USAEC Report SFIM-AEC-ET-CR-98008.

*Test Plan for the Phytoremediation Studies of Lead-Contaminated Soil from the Sunflower Army Ammunition Plant, DeSoto, Kansas.* USAEC Report SFIM-AEC-ET-CR-96198.

*Results of a Greenhouse Study Investigating the Phytoextraction of Lead from Contaminated Soils from the Sunflower Army Ammunition Plant, DeSoto, Kansas.* USAEC Report SFIM-AEC-ET-CR-98036.

## ◀ Plant Uptake and Weathering Studies on Composted Explosives-Contaminated Soil

Composting is a cost-effective way to reduce explosives in soil. Following composting, the soil is often returned to its original site. Long-term studies are needed to determine if transformation products from the explosives will weather, or if plants will extract these transformation products from the composted soil. These studies will provide the information necessary for environmental protection and compliance.

**Purpose**

To answer concerns regarding plant uptake of explosives transformation products; to conduct long-term weathering studies.

**Benefits**

Establishing the weathering characteristics and the susceptibility for plant uptake of explosives transformation products will facilitate regulatory approval of composting.

**Technology Users**

Army and Department of Defense installations with explosives-contaminated soil.

**Description**

Composting has been developed as a cleanup technology for explosives-contaminated soil. However, the technology does not achieve complete explosive mineralization, raising questions about its effectiveness. TNT transformation products appear to bind strongly to compost material and are not extractable. This project will test the availability of TNT transformation products from composted soil for plant uptake or release in the soil by plant root exudates. Studies will be conducted to determine the long-term stability of compost when exposed to varying weather conditions.

Composting explosives-contaminated soil costs about 40% less than incineration, a traditional cleanup method. Many installations are considering composting as a cleanup technology. However, the questions surrounding TNT mineralization keep the technology from being accepted without reservation by the academic and regulatory communities and the U.S. Army Corps of Engineers. Although the transformation products are not extractable,

concern exists that plants and long-term exposure to weather may release these products.

The project team consists of the U.S. Army Environmental Center (USAEC) as the lead agency and the Tennessee Valley Authority (TVA) as the performer. The project consists of four elements: shipping finished compost from Umatilla Army Depot Activity, Oregon, to TVA and producing control compost from soil and amendments from Umatilla at TVA; developing and testing analytical methods; conducting greenhouse studies; and conducting long-term weathering studies. All testing was conducted at TVA's facility in Muscle Shoals, Alabama.

Composting was used at Umatilla to treat explosives-contaminated soil from two lagoons. This composted soil was shipped to TVA for testing. Amendments used at Umatilla and uncontaminated soil from Umatilla were shipped to TVA to produce a control compost that was tested with the contaminated soil compost.

Finished compost from Umatilla was used in long-term weathering studies to determine what happens to compost when exposed to sunlight, weather and soil microbes. Different mixtures of compost and soil were placed in large pans and exposed to the elements. Leachate was collected and analyzed along with compost/soil samples over a three-year period. The compost/soil mixtures were not manipulated during the weathering study.

Nine plants were tested with the Umatilla compost and control compost. The vegetable crops tested included radishes, kale, bush beans, tomatoes and chives. The range crops tested included alfalfa, sorghum, red top and winter barley. Roots, stems and leaves, fruit, and soil around the root ball were tested.

Analytical methods exist for explosives in soil and water, but the ability of these methods to detect transformation products in plant-tissue extracts is not certain. Personnel from the U.S. Army Engineer Research and Development Center-Cold Regions Research and Engineering Laboratory (CRREL) and the U.S. Army Engineer Research and Development Center-Waterways Experiment Station (WES) helped chemists from USAEC and TVA determine the efficiency of these methods.

## ACCOMPLISHMENTS AND RESULTS

- Using information from WES, CRREL and USAEC, TVA developed an improved method for analyzing explosives residue in plant tissue.
- Weathering studies have been initiated and two years of leachate samples collected from rainfall on the pans. This study will continue through 1999.
- The control compost has been prepared.
- Lab and greenhouse testing to establish the maturity of the control and Umatilla compost is complete.
- Plant uptake studies are complete.
- A final report has been prepared.

## POINT OF CONTACT

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## PROGRAM PARTNERS

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Tennessee Valley Authority
U.S. Army Engineer Research and Development Center-Waterways Experiment Station
U.S. Army Engineer Research and Development Center-Cold Regions Research and Engineering Laboratory

## PUBLICATIONS

*Microbial Weathering Study of Composted Explosive-Contaminated Soil Obtained from the Umatilla Army Depot Activity*. SFIM-AEC-ET-CR-98042. October 1998.

*Results of a Study Investigating the Plant Uptake of Explosives Residuals from Compost of Explosive-Contaminated Soil Obtained from the Umatilla Army Depot Activity*. SFIM-AEC-ET-CR-98043. November 1998.

## Range Rule Risk Assessment – Range Rule Risk Model

The Department of Defense (DoD) has proposed a Range Rule that identifies a process for evaluating appropriate response actions on closed, transferred and transferring ranges. The U.S. Army Environmental Center is developing a methodology — known as the Range Rule Risk Model (R3M) — that will help DoD assess health and environmental risks posed by these ranges.

**Purpose**

To develop a risk assessment methodology for use in implementing the Range Rule.

**Benefits**

The model will serve as the DoD method for evaluating ranges under the Range Rule. It also may be used to evaluate unexploded ordnance (UXO) on ranges not covered specifically by the Range Rule and as a framework in parallel evaluations of human health risks stemming from physiologic and physical injuries.

**Technology Users**

DoD ranges being evaluated under provisions of the Range Rule.

**Description**

DoD has drafted a Range Rule that identifies a process for evaluating appropriate response actions on closed, transferred and transferring ranges. Response actions will address safety, human health and the environment. The Range Rule contains a five-part process that is not inconsistent with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and tailored to the special risks posed by military munitions and ranges. This process includes range identification, range assessment, range evaluation, recurring reviews, and range closeout.

To satisfy this process, the U.S. Army Environmental Center (USAEC) is developing a multicomponent risk evaluation methodology — R3M — that includes a risk management strategy, risk management framework, risk assessment methods and risk communication tools.

Many R3M components come directly from other methods used in range evaluation and response actions. The R3M effort serves to combine – or improve and develop – the necessary elements into a cohesive process that will be fully reviewed and approved by all DoD components and the Environmental Protection Agency (EPA).

The project includes several steps:

- Develop an interim method consisting of qualitative and semi-quantitative tools to reduce risks while meeting Range Rule requirements;
- Coordinate development with DoD, the EPA, the Range Rule Partnering Initiative and the public;
- Support partnering initiatives and Public Information Forums;
- Gain DoD and EPA acceptance of the R3M (as "interim final") before promulgation of the Range Rule;
- Develop validation criteria and validate the R3M during the early years of rule implementation;
- Revise the R3M based on validation and prepare the final R3M model, which includes methods to evaluate sites relative to site-closeout criteria.

## Accomplishments and Results

- Draft "strawman" method reviewed by DoD and EPA R3M teams.
- Developed an R3M draft version based on DoD, EPA and partnering initiative team comments.

## Follow-On Program Requirements

- Continue development of R3M draft version through DoD, EPA and partnering initiative teams.
- Approve draft R3M for public comment.
- Initiate preliminary validation effort.
- Initiate R3M validation and revision to final version.
- Produce the final model (one year after Range Rule promulgation).

## Point of Contact

Scott Hill

**PROGRAM PARTNERS**

U.S. Army Environmental Center
Department of Defense
Environmental Protection Agency
Range Rule Partnering Initiative

**PUBLICATIONS**

Public Information Forum fact sheets on the Range Rule.

## ◀ Remediation of Trichloroethylene-Contaminated Air Streams Using Biofiltration

Air stripping is an effective method of removing volatile compounds from water, but the volatile compounds must be controlled to prevent their release into the atmosphere. Biofiltration provides effective and total treatment at reasonable costs. Biofiltration of trichloroethylene-contaminated air streams can destroy such contaminants without creating secondary waste streams. Biofiltration will allow depots to support Department of Defense operations at lower costs.

**Purpose**

To demonstrate biofiltration's effectiveness in destroying trichloroethylene (TCE) removed from groundwater on a production-scale system at Anniston Army Depot, Alabama.

**Benefits**

Biofiltration will destroy contaminants without producing a secondary waste stream. Early economic evaluations predict that biofiltration will be less expensive than granular activated carbon (GAC). The system could be adapted to other industrial operations that produce solvent-contaminated air streams.

**Technology Users**

Any Department of Defense operation discharging solvent-contaminated air.

**Description**

Five Army installations and several Air Force bases currently use packed-column air strippers. Capture of TCE and other chlorinated solvents on GAC is effective, but expensive. Some air-stripper systems discharge to the air — which may be prohibited under new air regulations — and some capture the off gas on GAC. Biofiltration offers the ability to destroy air contaminants without producing a secondary waste stream.

The biofilter system is a scaled-up version of a 3 cubic-feet-per-minute system operating for the past three years at the Tennessee Valley Authority (TVA) to test different volatile compounds. The system uses propane gas as a co-substrate to feed the microorganisms, alternately feeding propane and TCE or other solvents. This system will handle methylene

chloride and other compounds that are toxic to methanotrophic systems. The filter bed is made of pelletized, composted chicken litter, pine bark, and chopped kenaf with pulverized limestone as a buffering agent. The bed at TVA has operated without additional materials or changes.

The Anniston Army Depot project consists of three phases: design, installation and testing. The design phase included the design and procurement of a system to treat 100 cubic feet per minute. The installation phase included installation of the system at one of the depot's air stripper systems. The treatment phase will include biofilter startup, acclimation, and operation for approximately 14 months. System acclimation will require approximately six weeks once the bed is inoculated with microorganisms.

The operational period will allow for testing all system parameters, such as: varying the contaminant concentration in the feed air stream; the most effective sequencing of the propane gas feed and the contaminant air stream; excess moisture and dry conditions in the biofilter; winter-to-summer temperature extremes; and the degree to which the system can be automated.

## Accomplishments and Results

The test plan and safety plan have been prepared and approved. The equipment design has been completed, the equipment procured and assembled, and the system installed at Anniston Army Depot. The system was ready for inoculation in November 1996, when Anniston Depot personnel notified TVA that the Environmental Protection Agency was going to conduct an installation groundwater dye test and that all pumps would be stopped until sometime in spring 1997.

The dye test was extended to July 1997. To avoid further delay, the state gave permission to feed surrogate TCE-contaminated air to the system to complete the acclimation period and initiate startup of the biofilter system.

The filter bed was inoculated; propane and surrogate feed were initiated to acclimate the bed and to obtain startup data. Initial data indicated TCE removal rates equal to or above those seen in smaller-scale tests at TVA.

An ISDN telephone line with voice and high-speed data transfer channels has been installed to transfer data electronically from the site to TVA and to remotely control the on-site gas chromatograph. System optimization testing using depot groundwater as the TCE source is near completion. Continuous operation will begin using the optimum parameters developed during the testing.

Testing will be complete in July 1999.

**FOLLOW-ON PROGRAM REQUIREMENTS**

- Complete testing and prepare a draft technical report.
- Complete brochure and video.

**POINT OF CONTACT**

Wayne Sisk

**PROGRAM PARTNERS**

U.S. Army Environmental Center
Tennessee Valley Authority
Anniston Army Depot, Alabama

## REMEDIATION TECHNOLOGIES SCREENING MATRIX AND REFERENCE GUIDE

Many government agencies produced documents to help their environmental project managers make intelligent decisions on cleanup technologies, but a lack of coordination led to duplication of effort among these agencies. The Federal Remediation Technologies Roundtable (FRTR) developed a guide to serve as a neutral platform from which to evaluate technologies.

**PURPOSE**

To monitor and update the *FRTR Remediation Technologies Screening Matrix and Reference Guide, Version III.*

**BENEFITS**

The guide is an unbiased medium from which users can find information on environmental remediation technologies. It provides current and cross-referenced information that saves users time and effort.

**TECHNOLOGY USERS**

Remediation project managers, government agencies, private organizations and academia.

**DESCRIPTION**

In the past, numerous government agencies, divisions and branches produced documents as tools for their environmental project managers. The FRTR sponsored production of the *FRTR Remediation Technologies Screening Matrix and Reference Guide, Version III* to eliminate the duplication of effort among its member agencies.

The document is electronic, allowing for quick and easy updating. The update effort committed Roundtable members to work together, leverage funds and resources, and prevent duplication of effort.

Technologies included in the guide were selected by the committee representatives, who had the option to serve as a review entity for each technology. After the document was written and reviewed, the information was formatted in HTML, integrated with all necessary hyperlinks and placed on the Internet for universal use.

The current World Wide Web version of the *FRTR Remediation Technologies Screening Matrix and Reference Guide*, located on the FRTR home page, replaced Version II. Web technology affords the Roundtable the opportunity to update and modify this "living" document. Each week, the guide is reviewed for broken links and outdated or incorrect information. New information is reviewed and evaluated for validity. This regular maintenance will ensure the document's integrity.

**Accomplishments and Results**

This project helps to demonstrate and foster cooperation among many federal agencies. Committee members established the personal relationships necessary to coordinate the update effort. There was a successful leveraging of funds from the Navy and Air Force. The Environmental Protection Agency donated a considerable amount of contractor support. Other agencies dedicated numerous in-house personnel hours toward the effort.

The document was released on the Web at www.frtr.gov/matrix2/top_page.html in November 1997. A poster version of the Screening Matrix became available in June 1998.

**Limitations**

The document is an electronic Web file, so there is no conveniently accessed paper version. Links and information must be continually monitored.

**Follow-On Program Requirements**

- Coordinate and execute continued update efforts.
- Continue to obtain committee concurrence.
- Long-term maintenance and monitoring.

**Point of Contact**

Dennis Teefy

**Program Partners**

U.S. Army Environmental Center
Federal Remediation Technologies Roundtable
Naval Facilities Engineering Service Center
Air Force Center for Environmental Excellence
Environmental Protection Agency
U.S. Geological Survey
Department of Energy

**PUBLICATIONS**

*Federal Remediation Technologies Screening Matrix and Reference Guide, Version III.* November 1997.

Federal Remediation Technologies Screening Matrix poster. June 1998.

## Slurry Biotreatment of Explosives-Contaminated Soils

Army industrial installations face high costs to clean up soil contaminated by past explosives operations. Remediating these sites is a prerequisite for environmental protection and beneficial reuse by the Army. These installations require cost-effective techniques to treat large volumes of explosives-contaminated soils. The U.S. Army Environmental Center has tested soil slurry biotreatment, or bioslurry, as an alternative to incineration.

### Purpose

To prove that biodegradation of explosives contamination in a soil slurry bioreactor is both possible on a large scale and an affordable alternative to incineration.

### Benefits

Contaminated soil can be treated and returned to its original location.

### Technology Users

Department of Defense (DoD) installations containing areas of explosives-contaminated soils.

### Description

Past production and handling of conventional munitions left explosives in soils at many Army installations. Depending on the concentrations of explosives — mainly trinitrotoluene (TNT), cyclonite (RDX) and cyclotetramethylene (HMX) — the affected soils can pose reactivity and toxicity hazards. Because these explosives can migrate from the soils into groundwater, the affected soils should be treated to eliminate threats to human health or the environment. Incineration, the traditional cleanup technology, is expensive and not readily accepted by regulators or the public.

The Army has searched since the 1980s for alternatives to incineration. Extensive tests have shown that bioremediation – the use of living organisms to remove pollutants from soil or water – can be a cost-effective treatment method. Biotreatment processes involve providing favorable conditions to enhance microbial metabolism, which can result in degradation of materials such as explosives, fuels and solvents.

The U.S. Army Environmental Center (USAEC) has field-tested several bioremediation methods, including windrow composting and soil slurry reactor biotreatment.

In 1995, USAEC conducted a soil slurry bioremediation test at Joliet Army Ammunition Plant (JOAAP), Illinois. Argonne National Laboratory performed the test. Conditions were established to encourage microorganism growth and demand for the contaminants. Because the process maintains optimum conditions and the slurry is mixed to maintain contact between the microorganisms and contaminants, slurry processes are faster than many other biological processes.

Bioslurry technology requires: soil excavation and screening to remove large rocks and plant roots; mixing soil with water to form a slurry in a reactor; and removal of the slurry from the reactor. Explosives degradation also requires a co-substrate (e.g., molasses), pH between 6 and 7, and aerobic/anoxic operation.

In this study, the native microbial population degraded explosives in soil. Four reactors (380 gallons each) were operated at JOAAP: a control reactor with no co-substrate; 20% and 10% weekly replacement (by volume) reactors; and a 5% daily replacement reactor. This design allowed investigation of different soil (and TNT) loading rates. The target soil slurry was 15% (weight/weight). Explosives concentrations in the soil were 2,000 to 8,000 mg/kg. Environmental conditions were identical for all reactors; temperature, pH, and dissolved oxygen were similar.

## Accomplishments and Results

At JOAAP, aerobic/anoxic bioslurry was used to reduce TNT, HMX and RDX concentrations in soil. Chemical analyses showed that soil slurry biotreatment of explosives-contaminated soil removed more than 99% of the contaminants. Metabolic fate studies of field samples showed up to 20% of the contaminant was completely mineralized and given off as $CO_2$. Another 55% of the contaminant showed up as organic acids and carbon fragments in the biomass, indicating a high degree of contaminant breakdown.

Other results:

- Aerobic/anoxic cycling enhances degradation (minimizes accumulation of metabolic intermediate byproducts).
- The product is suitable for land application.
- Process water can be recycled.
- Molasses was the most potent and cost-effective co-substrate.
- Degradation activity slows below 20 $^0$C.

The biological process is robust and can adapt to a variety of soil concentrations and temperatures. During normal operating conditions, soil loading can be increased to maximize throughput. In cold weather, minimizing additions of contaminated soil will enhance system survival.

In a separate study, USAEC examined the addition of surfactant to enhance the bioavailability of the contaminant in the solution. Treatability studies performed by the U.S. Army Engineer Research and Development Center-Waterways Experiment Station showed increased solubilization of TNT from soil with surfactant addition. USAEC field trials in 1995 using the same food-grade biodegradable surfactants showed faster initial reduction of TNT, but its byproducts accumulated in the reactor for longer periods, compared to biotreatment without surfactants. Consequently, process enhancements to bioslurry treatment of explosives-contaminated soils afforded by additional surfactant appear to be minimal.

In 1997, at Iowa Army Ammunition Plant (IAAAP), the DoD Environmental Security Technology Certification Program sponsored a field demonstration of aerobic/anoxic bioslurry treatment, side-by-side with a commercial anaerobic process, the Simplot Anaerobic Bioremediation Ex-situ (SABRE) process. Lined lagoon reactors were scaled up to treat up to 80 tons of soil in a batch. The demonstration provided performance results, a conceptual engineering design and cost estimates for full-scale application of slurry biotreatment. This data also applies to other explosives-contaminated sites.

## LIMITATIONS

- Oversized rocks and plant roots must be removed before bioslurry use.
- Organic co-substrate needed.
- pH greater than 6 to 7.
- Cold temperatures slow microbial metabolism rate.

**POINTS OF CONTACT**

Mark Hampton
Wayne Sisk

**PROGRAM PARTNERS**

U.S. Army Environmental Center
U.S. Army Engineer Research and Development Center-Waterways Experiment Station
Joliet Army Ammunition Plant, Illinois
Iowa Army Ammunition Plant, Iowa

**PUBLICATIONS**

*Feasibility of Biodegrading TNT-Contaminated Soils in a Slurry Reactor.* Technical Report CETHA-TE-CR-90062. U.S. Army Toxic and Hazardous Materials Agency (prepared by Argonne National Laboratory). June 1990.

*Feasibility of Biodegrading Explosives-Contaminated Soils and Groundwater at the Newport Army Ammunition Plant.* Technical Report CETHA-TS-CR-92000. U.S. Army Toxic and Hazardous Materials Agency (prepared by Argonne National Laboratory). June 1991.

***Available in print and on CD-ROM:***

*A Laboratory Study in Support of the Pilot Demonstration of a Biological Soil Slurry Reactor.* Technical Report SFIM-AEC-TS-CR-94038. U.S. Army Environmental Center (prepared by Argonne National Laboratory). July 1995.

*Field Demonstration of Slurry Reactor Biotreatment of Explosives-Contaminated Soils.* USAEC Report SFIM-AEC-ET-CR-96178. December 1996.

*Biotreatment of Explosives-Contaminated Soils: Field Demonstration of Multiple Slurry Reactor Processes.* USAEC Report SFIM-AEC-ET-CR-99009. June 1999.

## TOXICITY STUDIES FOR BIOTREATMENT OF EXPLOSIVES-CONTAMINATED SOILS

Windrow composting and soil slurry biotreatment are proven methods for removing explosives contamination from soil, but the world knows little about the toxicological properties of the byproducts of explosives biodegradation. New studies aim to provide objective data to support the reduction of toxicity in explosives-contaminated soils after biotreatment.

**PURPOSE**

To gather data on toxicological properties of the byproducts of explosive biodegradation, in order to determine the extent to which biodegradation reduces the toxicity of parent compounds.

**BENEFITS**

The studies provide objective data to support the reduction of toxicity in explosives-contaminated soils after biotreatment.

**TECHNOLOGY USERS**

Department of Defense installations with explosives-contaminated soils.

**DESCRIPTION**

Explosives contamination from past manufacturing and packing of conventional munitions presents the Army with a major environmental cleanup challenge. Explosives contamination is an environmental concern mainly because of its characteristic toxicity. However, relatively little is known about the toxicological properties of the byproducts of explosives biodegradation.

Chemical analyses show that both windrow composting and soil slurry biotreatment of explosives-contaminated soil can remove more than 99% of the contaminant. Another important test of biotreatment's effectiveness is to determine the extent to which biodegradation of the parent compounds reduces soil toxicity. This is consistent with the Superfund National Contingency Plan objective to evaluate the toxicity, mobility and volume-reduction effects of innovative treatment technologies.

In 1994, Oak Ridge National Laboratory (ORNL) evaluated

toxicity reduction in explosives-contaminated soil after composting biotreatment. Researchers used the Ames Assay, in which acetonitrile extracts from compost were exposed to salmonella to evaluate the reduction of mutagenicity from composting biotreatment. Aquatic toxicity, a measure of environmental health effects, was determined by exposing water leachates from compost to Ceriodaphnia Dubia.

From 1996 to 1997, ORNL repeated these tests on samples of explosives-contaminated soil after slurry biotreatment. In addition, trinitrotoluene (TNT), cyclonite (RDX) and their major metabolic byproducts were procured or synthesized and subjected to this combination of toxicity tests. The results significantly expanded the health-effects database on these compounds. Using the specific toxicity values of the compounds derived from these tests, researchers determined the probable sources of residual toxicity remaining in the treated slurry. Results are published in U.S. Army Environmental Center (USAEC) Report No. SFIM-AEC-ET-CR-96186.

In 1998, slurry samples from a field demonstration of aerobic and anaerobic bioslurry processes at Iowa Army Ammunition Plant also underwent a battery of toxicity tests. In addition to Ames and Ceriodaphnia tests, researchers performed Microtox, earthworm survival and plant-growth studies. The results were published in early 1999.

## Accomplishments and Results

Mutagenicity was substantially reduced in TNT-contaminated soils that underwent slurry treatment. Aquatic toxicity to Ceriodaphnia Dubia from TNT was virtually eliminated in the slurry product soil.

Slurry samples in which TNT byproducts were observed featured residual toxicity, attributable to the trace metabolites, potassium, bicarbonate and residual organic material from the bioslurry process. Potassium and bicarbonate are beneficial or benign to the environment, and the organic residues are substantially degraded in the environment. This suggests a product-management issue rather than a hazardous-material problem.

## Points of Contact

Mark Hampton
Wayne Sisk

**PROGRAM PARTNERS**

U.S. Army Environmental Center
Oak Ridge National Laboratory
Argonne National Laboratory

**PUBLICATIONS**

*Characterization of Explosives Processing Waste Decomposition Due to Composting.* ORNL/TM-12812. September 1994.

*Chemical and Toxicological Characterization of Slurry Reactor Biotreatment of Explosives-Contaminated Soils.* SFIM-AEC-ET-CR-96186. August 1998.

*Biotreatment of Explosives-Contaminated Soils: Field Demonstration of Multiple Slurry Reactor Processes.* SFIM-AEC-ET-CR-99009. June 1999.

## PINK WATER TREATMENT TECHNOLOGY RESEARCH TASK

Army ammunition plants produce explosives-contaminated water known as pink water. The plants meet discharge requirements by using granular activated carbon (GAC) to remove contaminants from pink water. The explosives-laden GAC – classified as a hazardous waste – is either regenerated or incinerated. Other treatment technologies are being sought to avoid the generation of this hazardous waste.

**PURPOSE**

To evaluate alternatives to GAC treatment of pink water.

**BENEFITS**

A cost-effective alternative to GAC absorption that does not generate hazardous waste when treating pink water will help Army installations meet stringent regulations pertaining to water effluent quality.

**TECHNOLOGY USERS**

Army ammunition plants.

**DESCRIPTION**

Army ammunition plants perform two functions that generate a waste stream known as pink water. These functions are (1) load, assemble and pack (LAP), and (2) demilitarization of munitions. Associated housekeeping and processing operations create the wastewater stream. Typical sources are wash down and wash out of munitions and laundering workers' clothing. Pink water typically contains photochemically active trinitrotoluene (TNT). The photoreactive products color the water. Besides TNT, pink water usually contains cyclotrimethylene-trinitramine (RDX) and cyclotetramethylene-tetranitramine (HMX). The composition of pink water varies, depending on process materials and operations. The reference value established in this work is 200 parts per million (ppm) dissolved energetic-related materials.

Army ammunition plants meet discharge requirements by using GAC to remove contaminants from pink water. The explosives-laden GAC, classified as a K045 hazardous waste, is either regenerated for reuse or incinerated for disposal. Technologies are being sought to avoid the generation of this hazardous waste.

Concurrent Technologies Corporation (CTC), the operating contractor of the National Defense Center for Environmental Excellence (NDCEE), under the initial Statement of Work from the U.S. Army Environmental Center (USAEC), was tasked to identify and evaluate the technologies as Phase I. This entailed surveying literature, assessing regulatory issues related to pink water, identifying candidate technologies, developing performance criteria and evaluation methods, selecting candidates for detailed evaluation, selecting the five best technologies based on the performance criteria and issuing a Phase I final report. The five technologies selected were Large Aquatic Plants (Biological) Treatment, GAC Thermophilic (Biological) Process, Fenton's Chemistry Process (Advanced Oxidation Process), Electrolytic Process (Mixed Oxidants) and Fluidized Bed Bioreactor Process.

Under Phase II, CTC was tasked to perform bench-scale tests on the five technologies using pink water generated from LAP operations at McAlester Army Ammunition Plant (MCAAP), Oklahoma, and pink water generated from demilitarization activities at Milan Army Ammunition Plant (MAAP), Tennessee. This entailed identifying vendors for the selected technologies, requesting test plans and safety plans from the vendors, determining critical process parameters and evaluation criteria, demonstrating and validating the bench-scale technologies, evaluating the technologies against the performance criteria, recommending the three best technologies for the pilot-scale demonstration, and issuing a Phase II final report.

Under Phase III, CTC is tasked to plan for operation of up to three technologies at 2 gallons per minute (gpm). This entails developing detailed engineering specifications, submitting an outline of a test and implementation plan, submitting an outline of a demonstration and validation proposal, and issuing a Phase III final report.

USAEC has written a Statement of Work to direct CTC to

perform Phases IV through VI. Phase IV is the design, installation and debugging of the demonstration plant(s). Activities include selecting engineering design subcontractors, preparing detailed design estimates, finishing detailed designs, selecting ammunition plant demonstration location(s), fabricating the demonstration plant(s), and issuing a Phase IV final report. Phase V is operating and evaluating the demonstration plant(s). Activities include operating the plant(s) for 180 days, evaluating them per the test plan, and issuing a Phase V final report. Phase VI is finalization and follow-through. Activities include revising operating documentation based on lessons learned in the pilot-scale demonstration(s), providing follow-on training, and providing follow-through support.

## Accomplishments and Results

The Phase I literature search is complete and a report has been submitted. Five technologies were selected for bench-scale testing. Phase II testing of the bench-scale technologies is complete and CTC has submitted an approved Phase II final report. CTC submitted an approved program management plan/task plan for Phase III. USAEC approved a Statement of Work for Phases IV through VI.

Other accomplishments:

- Developed detailed designs for three pilot test plants.
- Selected Milan Army Ammunition Plant for the full-scale demonstration.
- Fabricated the GAC Thermophilic (Biological) demonstration plants.
- Installed and debugged the GAC Thermophilic (Biological) demonstration plants.
- Began operation of the demonstration plants.

## Follow-On Program Requirements

- Operate demonstration plants for 180 days.
- Evaluate demonstration plants per test plan.
- Issue Phase V final report.

## Point of Contact

Louis Kanaras

**PROGRAM PARTNERS**

U.S. Army Environmental Center
Concurrent Technologies Corporation
National Defense Center for Environmental Excellence
McAlester Army Ammunition Plant, Oklahoma
Milan Army Ammunition Plant, Tennessee

**PUBLICATIONS**

*Phase I Report*, May 1995.

*Resource Utilization Plan.*

## ◀ Plasma Energy Pyrolysis System

The Army has identified various complex military waste streams that have significant costs associated with their disposal. Plasma arc technology can handle most of these waste streams in an efficient and cost-effective manner. The Plasma Energy Pyrolysis System (PEPS) project aims to build and improve on traditional plasma thermal technology.

**Purpose**

To build a continuously operating pre-production unit of a transportable PEPS.

**Benefits**

The PEPS program has focused on improvements to traditional plasma thermal technology and has realized a simple-to-control, automated operating system.

**Technology Users**

Department of Defense

**Description**

The U.S. Army has identified various complex military waste streams that have significant costs associated with their disposal. Such waste streams require further treatment to mitigate their hazardous waste characteristics following treatment by conventional methods (e.g., heavy metals leaching out of incineration ash). Another problem with these complex military waste streams is that the current hazardous-waste treatment solutions are controversial with the public and the Environmental Protection Agency (EPA). These include open burning (with its associated uncontrolled emissions) or incineration of medical wastes (with its associated concerns regarding emissions of dioxin, furan and other carcinogens).

Plasma arc offers hope in solving many of these problems. In FY 1997, Congress recommended $7.5 million in funding for the U.S. Army Environmental Center (USAEC) as program director responsible for overall technical and fiscal management for this effort. The U.S. Army Engineer Research and Development Center-Construction Engineering Research Laboratories (CERL) became the technical advisor for research and development of a cooperative project with

the Tennessee Valley Authority (TVA) to direct the acquisition, development, demonstration and validation of a PEPS in northern Virginia.

PEPS technology uses plasma arc torch energy in a reducing chamber to reduce – not combust – waste to a nonleachable glass slag and clean reusable gas. PEPS is a chemical reduction process, different from combustion (and without its byproducts). PEPS technology has been certified in California as an alternative to incineration for medical wastes, and in Washington state for low-level mixed wastes. The technology is flexible enough to run in reduction or combustion modes, can reform gas into a pyrolysis product/fuel gas, possesses a smaller footprint than plasma-assisted incineration systems, and allows for continuous feeding.

Following successful demonstration, project deliverables will be obtained that will allow implementation on a wider basis.

## Accomplishments and Results

- Awarded contract to Vanguard Research Inc.
- Selected a private facility in Newington, Virginia, as a demonstration site.
- Identified medical waste and spent blast media as demonstration waste streams.
- Prepared and issued an Environmental Assessment (EA) and Finding of No Significant Impact (FONSI).
- Received approval of the EA and FONSI.
- Received approval of required permits.
- Completed site preparation activities.
- Built the PEPS system.
- Completed equipment inspection test.

## Limitations

This technology costs more than conventional technologies and should find its niche in the "hard to treat" wastes.

## Follow-On Program Requirements

- Conduct technology demonstrations with medical waste and spent blast media.
- Produce final technical report.
- Produce final operations and maintenance manual.
- Produce final cost and performance report.
- Complete deactivation and cleanup activities.

**POINT OF CONTACT** Louis Kanaras

**PROGRAM PARTNERS**

U.S. Army Environmental Center
Tennessee Valley Authority
Vanguard Research Inc.
Plasma Energy Applied Technology
U.S. Army Engineer Research and Development Center-Construction Engineering Research Laboratories

## FLASHJET® COATINGS REMOVAL PROCESS

The Defense Department is looking for alternatives to chemical paint removal and media blasting. The FLASHJET® coatings removal process, a xenon-flashlamp and frozen carbon dioxide combination patented by The Boeing Company, is a cost-effective and timesaving technology with potential military application.

**PURPOSE**

To demonstrate the FLASHJET® coatings removal process for military use.

**BENEFITS**

The FLASHJET® process offers low life-cycle costs, saves time and reduces the amount of hazardous waste generated during depainting.

**TECHNOLOGY USERS**

Department of Defense (DoD) depots and depot-level maintenance shops.

**DESCRIPTION**

Efforts are underway within DoD to find alternatives to chemical paint removal and media blasting. In the U.S. Army Environmental Requirements and Needs Report, requirements for finding alternatives to chemical paint removal and media blasting include Contaminated Blast Media (2.3.n); Hazardous Air Pollutant Emission Control (2.1.g); and Alternate Paint Stripping Chemicals of Military Interest (3.2.h). The U.S. Navy requirements relating to depainting activities include Control/Reduce Emissions from Coating, Stripping and Cleaning Operations (2.I.1.g); Control of VOC and HAP Emissions (2.I.1.q); and Non-hazardous Coating System Removal (3.I.5.a). U.S. Air Force depainting requirements include: Substitute for Methylene Chloride Paint Strippers (449); Decreased Waste Generation from Plastic Media, Sand, Walnut Hull and Other Blasting Depaint Operations (808); and New Paint-Stripping Methods Have to Be Identified to Reduce Hazardous Waste and Cost

(814). All of these requirements are considered high-ranking needs within their respective service.

As an environmentally preferred coatings-removal process, FLASHJET® eliminates the use of hazardous air pollutant (HAP) chemicals and blasting media. The FLASHJET® process does not use any hazardous materials during the coating-removal stage, thus minimizing the potential for hazardous airborne dust and cutting the cost of paint removal.

FLASHJET® combines two depainting technologies in one process: a xenon-flashlamp and a continuous stream of recycled carbon dioxide pellets. The process also includes an effluent capture system that collects effluent ash and organic vapors. Effluent ash is captured by a series of high efficiency particulate air (HEPA) filters; organic vapors are processed through an activated charcoal tank. The process is fully automated and requires limited worker involvement.

The FLASHJET® system includes six components: the flashlamp and stripping head; the manipulator robotic arm; the computer processed cell controller; the effluent capture system; the carbon dioxide pelletizer; and the flashlamp power supply. The xenon-flashlamp is the primary coatings-removal step. The xenon-flashlamp emits low-pressure xenon gas and creates a high-intensity flash that ablates the coating from the surface. Light energy generated from the xenon-flashlamp pulses 4 to 6 times per second. The amount of coating ablated is directly proportional to the amount of energy put into the system. The process can be controlled to remove as little as .001 inches of coating and as much as .004 inches of coating. This control factor can be an asset when topcoat removal is required, but the underlying primer must remain on the substrate.

The carbon dioxide pellet-blasting technology is not a direct form of pellet blasting. The continuous stream of carbon dioxide pellets has two purposes. First, it cools and cleans the substrate, keeping the substrate at an acceptable temperature while the xenon-flashlamp ablates the coating. Second, the stream keeps the flashlamp clear of any coating by "pushing" the coating away from the flashlamp and toward the effluent capture system. All carbon dioxide emitted during the process is captured from other industrial

type sources, converted into liquid carbon dioxide and reused.

The effluent capture system collects all effluent ash and organic vapors generated during ablation. Effluent ash is vacuumed into the capture system, separated by size in a particle separator, and captured in a series of HEPA filters. Organic vapors are captured and processed through an activated charcoal scrub and emitted to the atmosphere with less than 10 parts per million light hydrocarbon emission

The FLASHJET® process has several advantages over other commonly used depainting technologies. The only wastes generated are coating ash and spent HEPA filters. Compared to common media blasting and chemical paint-removal operations used at military depots, the FLASHJET® process has the potential to substantially reduce the amount of waste a facility generates.

The former McDonnell Douglas Corporation conducted life-cycle cost comparisons for the F/A-18A fighter aircraft. The estimated life-cycle cost for FLASHJET® was $2.89 per square foot. Plastic media blasting was calculated at $15.40 per square foot and chemical depainting was calculated at $33.61 per square foot. Although the FLASHJET® process has a high acquisition cost, it is offset by an attractive life-cycle cost. These costs are calculated over a 15-year period.

The process is beginning to gain acceptance within DoD. The Air Force is on contract to install a system at the Warner-Robins Air Logistics Center in Georgia for stripping off-aircraft components. Corpus Christi Army Depot in Texas is also on contract to install a system for stripping the Army UH-60 Black Hawk and the Navy SH-60 Seahawk rotary wing aircraft. The FLASHJET® system installed at the Naval Air Station-Kingsville, Texas, for the Navy's T-45 program will be operational by the end of 1998. All three Naval Aviation Depots have a FLASHJET® system in their facility equipment plans.

## Accomplishments and Results

FLASHJET® has undergone seven years of extensive metallic and composite substrate panel testing for qualification purposes. The Navy approved the process for

use on metallic fixed-wing aircraft, with composite fixed-wing aircraft approval expected within the next year.

## Limitations

The main limitation of the FLASHJET® process is its high acquisition cost. One system costs $2.6 million, not including the expense of retrofitting an existing structure or constructing a new building. The system cannot access angles and tight corners due to the configuration of the stripping head; this could result in using more than one pass and increasing the xenon-flashlamp energy input, which could reduce the coating removal rate. The stripping head is approximately 15 inches long, including the xenon-flashlamp, the carbon dioxide pellet stream nozzles, the containment shroud and the bump sensors. A secondary depainting process is needed for areas inaccessible to the stripping head. This problem, however, is commonly found with other depainting technologies. The Boeing Company is developing a smaller stripping head for removing coatings in hard-to-reach areas.

## Follow-On Program Requirements

Requirements for FY 1999 will concentrate on Phase II testing on military ground/fighting vehicles and equipment, and remaining Phase I high-cycle fatigue qualification testing. Phase II testing will demonstrate the FLASHJET® process on a Bradley fighting vehicle, a High Mobility Multipurpose Wheeled Vehicle and a command and communications shelter. Remaining Phase I testing includes incorporating suggestions on the Joint Test Protocol given by the U.S. Army Aviation and Missile Command Program Executive Officers-Aviation Office.

## Point of Contact

Dean Hutchins

## Program Partners

U.S. Army Environmental Center
Department of Defense Environmental Security Technology Certification Program
Department of Defense program managers
Anniston Army Depot, Alabama
Corpus Christi Army Depot, Texas
Patuxent River Naval Air Station, Maryland
Naval Aviation Depot – Cherry Point, North Carolina

Warner-Robins Air Logistics Center, Georgia
Fort Hood, Texas
Arizona Army National Guard
National Defense Center for Environmental Excellence
The Boeing Company

## PUBLICATIONS

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Briehan, David W., *Xenon Flashlamp and Carbon Dioxide Advanced Coatings Removal Prototype Development and Evaluation Program.* MDC 92B0479. McDonnell Douglas Corp. for Warner-Robins Air Logistics Center. 1992.

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Briehan, David W., and James Reilly. *Xenon-Flashlamp and Carbon Dioxide Coatings Removal Development and Evaluation – U.S. Navy Add-on Program Final Report.* MDC 93B0341. McDonnell Douglas Corp. for NADEP Jacksonville. 1993.

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## ◀ Hydraulic Fluid Recycling

The Army uses hydraulic fluid when operating various types of equipment. Installations face disposal costs for used hydraulic fluid. By recycling hydraulic fluid to Army specifications, installations will reduce waste quantity and disposal charges.

**Purpose**

To reduce costs and increase readiness by implementing an affordable system to recycle used hydraulic fluid to Army specifications.

**Benefits**

Extending the life of fire resistant hydraulic fluid (FRH) saves money. Maintenance schedules would be easier to follow because procurement of FRH would decrease. The recycling systems' in-line monitors provide a simple means of determining FRH batch cleanliness, assuring maintenance personnel of the quality and readiness of the fluid. The machines are user-friendly, cost-effective and able to meet military needs.

**Technology Users**

Army depots and Department of Defense (DoD) facilities.

**Description**

Hydraulic fluid is disposed of as a hazardous waste. The military uses large quantities of FRH in a variety of materials from bridge launchers to forklifts.

New FRH costs roughly $10 per gallon. It costs less than $3 to reclaim a gallon of FRH. Through recycling, the procurement needs and disposal volume of new fluid would be reduced 75%. Many installations could recoup the cost of their initial investment in the first year of reclamation.

Field demonstrations and analyses show that when mixed with 25% virgin material, recycled fluid meets all specification performance requirements. The demonstrations also show a need for real-time fluid analysis. To better meet the Army's needs, in-line sensors were used to determine the particulate and water content of the fluid being recycled.

FRH recycling began with research in the viability and field demonstration of commercially available recycling units.

Further analysis determined that some units produce FRH meeting military specifications. Cooperative Research and Development Agreements (CRADAs) were established to leverage government and private efforts to improve the design of the recyclers while increasing user-friendliness. In-line monitors were incorporated and tested for accuracy.

Installations can use a payback spreadsheet to determine the feasibility of using this technology.

## Accomplishments and Results

CRADAs were signed with Pall Aerospace and SESCO Inc. to add in-line sensors to their hydraulic fluid recyclers. The Pall Aerospace unit has been validated and is available for full-scale use.

The hydraulic fluid recycling draft report and final report of the monitoring unit test has been submitted. A fact sheet has been completed on hydraulic fluid recycling. Articles have appeared in the *Environmental Update* and the *Army Logistician.*

## Limitations

Hydraulic fluid recycling requires improved cleanliness, organization and used-fluid separation. The installation must make a commitment to good housekeeping. Burnt hydraulic fluid cannot be reclaimed.

## Follow-On Program Requirements

Technology transfer and implementation of the Pall system.

## Point of Contact

Dennis Teefy

## Program Partners

U.S. Army Environmental Center
U.S. Army Tank-automotive and Armaments Command Fuels and Lubricants Technology Team
Pall Aerospace
U.S. Army Aberdeen Test Center

## Publications

*Pall Hydraulic Fluid Recycling Unit with Automatic Cleanliness Monitoring System.* CRADA Report.

Purdy, Ellen M., Ralph B. Mowery, and Sgt. Donna M. Rutkowski. *MIL-H-46170 Hydraulic Fluid Recycling Field Demonstration*. TARDEC Technical Report No. TR-13731. U.S. Army Tank-automotive and Armaments Command Research and Development Center. Warren, Michigan. October 1996.

*User's Guide for Recycling Military Hydraulic Fluid.* U.S. Army TACOM, Mobility Technology Center-Belvoir. Fort Belvoir, Virginia. May 1997.

## Retrofitting Conventional Gravity Oil/Water Separators

Oil/water separators are used extensively throughout the Army to pretreat wastewater. Some separators do not perform as expected for a variety of reasons. However, certain measures can be taken to retrofit an oil/water separator and help it meet wastewater discharge limits.

**Purpose**

To demonstrate and validate the retrofitting of an oil/water separator (OWS) with a vertical tube coalescer (VTC).

**Benefits**

In some circumstances, retrofitting an OWS with a VTC is an economically feasible alternative to replacement. By retrofitting an OWS, one could expect lower discharge of total petroleum hydrocarbons (TPH), ability to increase water flow, and compliance with regulatory discharge limits.

**Description**

An OWS is used to pretreat wastewater before it is discharged to a sanitary sewer or the environment. The separators are typically associated with washing activities but are also found in other industrial and maintenance activities. The primary use of the OWS is to remove most of the oily waste from the waste stream before final treatment.

Through improper design, lack of proper operation and maintenance, and misuse, an OWS may allow discharges of wastewater above the regulatory limit. When the problems are corrected and the OWS still fails to meet the limit, the installation may install a new OWS system or retrofit the current system.

The retrofit material of concern was the VTC, a pack of oleophilic (oil attracting) polypropylene tubes that collects oil globules on its surface. As the size of the globule increases, the quicker the oil separates from the waste stream. This allows for more efficient separation.

The demonstration of the retrofit technology was done in two parts: A case study and a bench-scale study.

During the investigation of this technology, it was learned that an Army installation retrofitted an OWS with a VTC.

With the cooperation of the installation, the U.S. Army Environmental Center and U.S. Army Engineer Research and Development Center-Construction Engineering Research Laboratories used the OWS as a case study. Information was gathered on the maintenance, efficiency and lessons learned.

To validate that the VTC fulfilled the needs of the retrofit, a controlled bench-scale test was conducted through the U.S. Army Aberdeen Test Center. Wastewater was run through the bench-scale apparatus in a variety of concentrations and flow rates. These test runs were done with and without the VTC in the apparatus, allowing researchers to determine the performance of the retrofit in a variety of typical wastewater situations.

## Accomplishments and Results

***Case Study***

- Found the VTC retrofit increased the ability of the OWS to remove oil.
- Produced a report detailing the case study.
- Provided information to the installation to aid in the optimization of the OWS.
- Gathered a variety of lessons learned.

***Bench-Scale Test***

- Found the VTC increased the efficiency of the OWS by an average of 53%.
- The VTC performed as expected.
- Produced a final report.

## Limitations

Retrofit technologies increase the amount of operation and maintenance. Systems will work only if the OWS is properly designed. The tubes are prone to clogging with grit and dirt, and they are sensitive to extreme heat. Installations also may need special cleaning equipment.

## Follow-On Program Requirements

- Technology transfer and information exchange.
- Support installations with retrofit inquiries.

## Point of Contact

Dennis Teefy

**PROGRAM PARTNERS**

U.S. Army Environmental Center
U.S. Army Aberdeen Test Center
U.S. Army Engineer Research and Development Center-Construction Engineering Research Laboratories
U.S. Army Garrison, Fort Lee, Virginia
AFL Industries

**PUBLICATIONS**

Wang, Dr. Zhao, and Donald Zelzany. *Replacing or Retrofitting Oil/Water Separators*. SFIM-AEC-ET-CR-98022. July 1998.

Klara, Paul. *Final Report of the Coalescing Tubes Test for Oil/Water Separators.* SFIM-AEC-ER-CR-98030. September 1998.

## ◀ Retrofitting Existing Oil/Water Separators

Wastewater generated by washing activities typically flows to an oil/water separator before discharge or primary treatment. Effluent from the separator must comply with water-quality limits mandated by the Clean Water Act or by local pretreatment programs. A technology offered by industry uses specially designed vertical tube coalescer packs that enhance the effectiveness of existing gravity oil/water separators.

### Purpose

To determine the ability of the vertical tube coalescer (VTC) to increase the efficiency of an oil/water separator (OWS), and gather information on its benefits and limitations.

### Benefits

Retrofitting an OWS avoids the costs of OWS removal, replacement and permitting. It also is a cheap and effective way to reduce the concentration of oil entering a sanitary sewer.

### Description

Wastewater discharges stemming from maintenance of Defense Department tactical and nontactical vehicles and equipment must comply with Clean Water Act treatment and pretreatment requirements. Treatment of this wastewater has traditionally focused on the removal of sediment and petroleum, oils and lubricants (POLs).

According to its manufacturer, the principal function of the VTC is to provide a coalescing surface on which minute oil globules can agglomerate. The coalesced oil then rises to the water's surface for skimming. The tube pack makes possible one of two goals, or the compromise between them: (1) reduce the oil content of the water, or (2) increase the flow through the separator without degrading performance. The vertically positioned tubes, made of perforated polypropylene, have oleophilic (oil attracting) properties. Suspended particles of oil collect on the tubes' surface and migrate up. If the globules become sufficiently large and buoyant, they rise through the tubes. The vertical orientation of the tubes contributes to more efficient separation.

**ACCOMPLISHMENTS AND RESULTS**

The U.S. Army Environmental Center and U.S. Army Aberdeen Test Center observed increased performance because of the VTC. The demonstration helped determine that retrofitting oil/water separators can be a feasible and cost-effective alternative to replacement.

**LIMITATIONS**

Operation and maintenance requirements of the OWS increase when higher amounts of sediment and oil are removed from the waste stream. The tubes must be periodically removed and cleaned. Without proper maintenance, the tubes can short the separator's circuitry and allow wastewater to flow through without proper treatment.

**FOLLOW-ON PROGRAM REQUIREMENTS**

This technology is in the transfer phase. The final report must be distributed and support given to the field.

**POINT OF CONTACT**

Dennis Teefy

**PROGRAM PARTNERS**

U.S. Army Environmental Center
U.S. Army Aberdeen Test Center
AFL Industries

**PUBLICATIONS**

Klara, Paul. *Final Report of the Coalescing Tubes Test for Oil/Water Separators.* September 1998.

## WASHRACK RECYCLE TREATMENT SYSTEMS EVALUATION

Washracks are used for cleaning Army tactical vehicles for inspection, maintenance and mission readiness. Washrack recycle treatment systems are sold as alternatives to standard washracks. The U.S. Army Environmental Center evaluated the ability of commercial washracks to improve environmental compliance while meeting mission needs.

**PURPOSE**

To field-test two commercially available closed-loop washrack recycle treatment systems, and gather information on costs associated with moving to a closed-loop system.

**BENEFITS**

Closed-loop washracks have a variety of apparent benefits when operating at an optimal level. The discharge of wastewater to a sanitary sewer is eliminated; the cost of permitting and monitoring discharges then decreases. Using recycled wastewater from previous wash events decreases the need for external water. The demonstration affords a chance to document costs, experiences, limitations and recommendations.

**TECHNOLOGY USERS**

Maintenance shops, administrative motor pools, Department of Defense (DoD) vehicle depots, and laboratory and testing facilities.

**DESCRIPTION**

Installations have purchased washrack recycle treatment systems to eliminate certain environmental concerns. The concept of reducing the amount of wastewater treatment, discharge and monitoring is very appealing. Washrack recycle systems are advertised as the answer to this wastewater issue. Unfortunately, no independent information existed on the reliability or maintainability of these systems.

The U.S. Army Environmental Center (USAEC) partnered with the U.S. Army Engineer Research and Development Center-Construction Engineering Research Laboratories (CERL) and U.S. Army Aberdeen Test Center (USAATC) to evaluate washrack recycle systems for Army use. The demonstration took place at the U.S. Army Garrison,

Aberdeen Proving Ground (APG), Maryland. This situation was ideal because the installation was constructing a washrack recycle treatment system. The washrack facility was built and two units were tested, each for five months.

All aspects of reliability, maintainability, treatment performance and water quality were tested and evaluated.

## Accomplishments and Results

USAEC and USAATC signed a Memorandum of Agreement with private industry for loan of a washrack recycle system. The recycle units were tested, the data was evaluated and a final report was produced.

Each system showed numerous deficiencies and design flaws. Necessary scheduled maintenance was significant and the systems often ceased to operate. Neither system operated in complete recycle mode and discharges to the sanitary sewer occurred. There was a problem with biological growth in the wastewater.

## Limitations

Washrack recycle treatment systems are not recommended for Army use unless:

- Connecting the washrack to a sanitary sewer is too expensive or difficult;
- The washrack is in a water-shortage area;
- Permitting requirements make the use of the system cost-effective.

## Follow-On Program Requirements

- Continue technology transfer.
- Support installations with washrack recycle treatment system reviews.
- Distribute final report.

## Point of Contact

Dennis Teefy

## Program Partners

U.S. Army Environmental Center
U.S. Army Aberdeen Test Center
U.S. Army Engineer Research and Development Center-Construction Engineering Research Laboratories
Landa Incorporated
RGF Environmental Group

**PUBLICATIONS**

Gerdes, Gary, Kenneth Hudson, Peter Stemniski, and Edward Engbert. *Evaluation of Two Washrack Recycle Treatment Systems*. SFIM-AEC-ET-98009. July 1998.

## Remote Sensing Technology Users' Guide

Modern, effective and efficient management of Army lands requires the use of remotely sensed imagery. Until the U.S. Army Environmental Center and U.S. Army Engineering Research and Development Center-Topographic Engineering Center developed the *Remote Sensing Technology Users' Guide*, no concise guide for the process of remote-sensor selection and procurement existed. The guide provides a systematic approach for everyone from the least to the most experienced users.

**Purpose**

To update the *Remote Sensing Technology Users' Guide* to include sections on World Wide Web sources, the latest available imagery (including recently declassified imagery) and digital orthophotos.

**Benefits**

Periodic updating of this manual will provide the most beneficial remote-sensing information to installation land managers in reader-friendly language. The use of properly selected and procured imagery will result in cost savings to the Army.

**Technology Users**

Army and Department of Defense (DoD) training land managers, and non-DoD land managers.

**Description**

This document is an organized guide to currently available and near-term remote sensors for land managers. Inexperienced and advanced users alike can use this document as a source of information and guidance when deciding on remote sensing technologies.

The guide's ***Selection Key*** contains three sections: vegetation, soils and land management objectives. Each section is organized by ecoregion, allowing users to identify the imagery that meets their needs. Many management objectives within the keys contain references to applicable articles describing scientific investigations. These

articles can provide resource managers with information and ideas on how to approach their projects.

***Sensor fact sheets*** provide details on each sensor and include information on spatial resolution, bandwidth, cost, revisit time and other image characteristics. The sheets can be removed from the binder to allow side-by-side comparison of the sensors identified in the Selection Key.

Sample ***Statements of Work*** and sources of acquisition assistance are included. Land managers can use these examples to obtain imagery themselves or determine if they need assistance.

Brief explanatory sections cover the elements that make up a remotely sensed image and how image interpreters use those elements to extract information. Appendices (more appropriate for advanced users) discuss spectral information and imagery sources. A bibliography lists the literature cited in the text and the Selection Key.

This guide will be successful if it helps resource managers better understand the nature of remotely sensed imagery and how to select specific sensors for specific tasks; decide whether to work independently or to use contractor expertise, find literature that discusses case studies similar to theirs; interpret historical imagery; and locate free or inexpensive imagery owned by government agencies.

## Accomplishments and Results

Version 1.0 was produced in January 1997. An overwhelmingly positive response was received from the major commands and installations.

## Follow-On Program Requirements

As new technologies become available to installation users, periodic updates to the guide will be necessary.

## Point of Contact

Terri Bright

## Program Partners

U.S. Army Environmental Center
U.S. Army Engineer Research and Development Center-Construction Engineering Research Laboratories
U.S. Army Engineer Research and Development Center-Topographic Engineering Center

# V PROGRAM FOCUS: RANGE XXI

Through the Range XXI program, a multi-agency partnership led by the U.S. Army Environmental Center and the U.S. Army Training Support Center, P2&ETD provides major command and installation range managers with cost-effective tools for complying with environmental laws and regulations while sustaining realistic training areas.

Range XXI initiatives include devices to trap and recycle bullets, firing range designs that prevent erosion and the spread of pollutants, "green" ammunition, guides to environmentally responsible range operations and management, and technologies that separate lead and other heavy metals from soil.

## Green Ammunition

Millions of small arms rounds are fired annually on military ranges during training and testing activities. These projectiles contain lead, a federally listed toxic material, and may pose an environmental risk to soil, sediments, surface water and groundwater. Replacing lead in conventional projectiles with a tungsten core will minimize environmental compliance impacts on training and help avoid costly cleanup efforts.

### Purpose

To provide the Department of Defense (DoD) with small-caliber service ammunition that will meet U.S. and NATO performance standards while eliminating lead in the projectile core.

### Benefits

This program will revolutionize small-caliber ammunition. The next generation of ammunition, while benign to the environment, potentially offers enhanced lethality and functionality. Environmental restrictions on training U.S. military personnel will be minimized. Training realism and effectiveness will be greatly enhanced, while future cleanup costs may be eliminated. Furthermore, DoD will be the international leader in these technologies and the environmental stewardship shown will enhance both public image and trust.

### Technology Users

U.S. Army Armament Research, Development and Engineering Center (ARDEC), Small Caliber Ammo Branch
U.S. Army Infantry Center (USAIC)
U.S. Army Research Laboratory (ARL)
Naval Surface Warfare Center-Crane (NSWC)
Department of Energy (DOE) Oak Ridge National Laboratory (ORNL)
DOE-Los Alamos National Laboratory (LANL)
DOE-Kansas City Facility (KCF)

## Description

Lead in soil, sediment, surface water and groundwater has been confirmed through investigations at Army, Navy, Marine Corps and Air Force small arms ranges throughout the United States and Europe. Lead uptake studies in vegetation at a Marine Corps range in Quantico, Virginia, showed lead levels as high as 23,200 parts per million (ppm). Remediation has proven to be extremely expensive. Furthermore, inspections of National Guard indoor ranges during 1986 to 1988 resulted in 812 ranges being shut down due to high levels of lead contamination, both surface and airborne. Those ranges will require costly renovations to meet Environmental Protection Agency (EPA) and Occupational Safety and Health Administration (OSHA) standards.

About 689 million rounds of small arms ammunition (.22-caliber through .50-caliber) are fired annually during DoD training, with an additional 10 million rounds fired annually by DOE. The annual amount of heavy metal introduced into the environment from this training is approximately 3 million pounds.

The lead projectile cores and compounds used in primers create dust and fumes when fired, exposing shooters and range operators to dangerously high levels of airborne lead. Studies from the U.S. Army Center for Health Promotion and Preventive Medicine show that projectiles account for 80% of airborne lead released on firing ranges, while the remaining 20% comes from primer combustion. The studies also indicate that 40% of inhaled lead is dissolved in the bloodstream and 10% is absorbed directly by the body. Once in the body, lead is very difficult to remove.

The Joint Service Non-Toxic Ammunition Working Group was established in 1995 by ARDEC as a multiservice cooperative forum of DoD, DOE, private industry and academia experts. ARDEC is responsible for overall program management and execution.

The U.S. Army Environmental Center (USAEC) has funded efforts to eliminate lead from the projectile core. This focus is due to the lead buildup from rounds in small arms range impact areas, which could result in noncompliance with environmental laws and regulations.

The next generation of small arms projectiles will rely on innovative materials to reproduce and improve upon the physical, ballistic and mechanical properties of lead. Composite materials, such as metal powders in nylon or high-density metal particulates bonded with light metals, are being examined as nontoxic replacements for lead.

Concurrent with the USAEC-funded demonstration of an alternative 5.56 mm projectile, other efforts will target the toxic components in the cartridge primer and manufacturing process.

Of primary concern at outdoor ranges is the introduction and dispersion of tungsten throughout the environment. Development of the toxicity and environmental recovery information to support recycling or closed-loop use of the materials, and data on environmental effects, are being determined. Additional leaching, environmental corrosion and biological uptake tests will be performed to fully define stability and mobility characteristics. Study results will guide projectile formulation such that all materials will be stable and recoverable. Projectile design, constituent materials and processing will be optimized to support the maximum recovery and recyclability of this next generation of projectile materials. USAEC will specify recovery and recycle methods and provide for the pilot-scale demonstration. Adequate information regarding the use, release and mobility of the high-density constituents under consideration, specifically tungsten, is considered crucial for acceptance.

Demonstrating the producibility of the lead-free projectile is as critical as the performance demonstrations. If the items cannot be produced in a cost-effective, environmentally compliant fashion, the technology will fail. Lake City Army Ammunition Plant (LCAAP) in Missouri is the Army's principal supplier of small-caliber ammunition. The producibility testing of the proposed nontoxic projectile will be performed at LCAAP. Additionally, other environmental issues regarding production methods, machinery and support materials for small-caliber ammunition manufacture will be addressed.

Producibility testing will be used to minimize production costs and provide feedback to the projectile and primer designers. Production rates of 1,200 items per minute require special consideration in item design and manufacture. Performing producibility tests will assure that item unit-costs stay within 10% of current ammunition production costs.

USAEC plans to provide funding for qualification tests and type classification of the new 5.56 mm cartridge for Armywide implementation. At the start of Phase II, the composite materials identified in Phase I will be refined. Approximately 100,000 rounds of the successful candidates from Phase I (i.e., tungsten/nylon and tungsten/tin) will be purchased from Texas Research Institute and Powell River Laboratories, Inc. A task order contract will be prepared for LCAAP to assemble and load M855 cartridges using the composite projectiles. Cartridges from each lot will be subjected to standard production verification testing to ensure their safety and performance. All cartridges will then be shipped to the Naval Surface Warfare Center in Crane, Indiana, for qualification testing.

Qualification test requirements and ammunition quantities will be finalized. Tests not conducted during Phase I that have the highest likelihood of revealing projectile-related deficiencies will be conducted first. Some of these tests will include environmental conditioning (hot and cold temperature cycling), rough handling, and barrel erosion. These tests will narrow the selection to one material. The remainder of the testing will include, but not be limited to, electronic pressure, velocity and action time, dispersion and penetration. If both candidates meet all requirements, both will be considered qualified alternate materials.

During Phase III, the technology will be transitioned to the 7.62 mm and the 9 mm projectiles, and demonstration/testing of those configurations will be performed. Concurrent with the manufacture and testing activities, a corrosion and life-cycle cost analysis will be performed for all three calibers. This effort will examine product cost from raw material processing through manufacture, use, and eventual disposal or recycling.

## Accomplishments and Results

During Phase I, USAEC and ARDEC demonstrated the viability of seven nondevelopmental item formulations to replace lead in the 5.56 mm projectiles. Composite materials tested during Phase I consisted of tungsten bonded with light metals (i.e., tin, zinc) or synthetics (i.e., nylon). Composites were subjected to a high-speed assembly and loading process to produce net shape cores with physical properties similar to lead. Projectiles underwent ballistics performance testing for dispersion, penetration, electronic pressure, velocity and action time. Phase I isolated two candidates suitable for replacing the current 5.56 mm service round. Toxicity studies on tungsten are being analyzed at Oak Ridge National Laboratory and the Army Center for Health Promotion and Preventive Medicine.

The final report of the demonstration of lead-free alternatives for 5.56 mm ammunition was submitted to USAEC in February 1997. Both configurations will advance through Phase II to production unless one proves unfeasible.

## Follow-On Program Requirements

- Complete Phase II (select final candidates).
- Complete Phase III (transition the technology to other calibers).

## Points of Contact

Dave McFerrern
Terri Bright

## Program Partners

U.S. Army Environmental Center
U.S. Army Armament Research, Development and Engineering Center
Lake City Army Ammunition Plant, Missouri
Oak Ridge National Laboratory
Naval Surface Warfare Center, Crane, Indiana
Naval Surface Warfare Center, Indian Head, Maryland

## UXO Degradation Impact Analysis

As part of their efforts to find and address unexploded ordnance (UXO) on training ranges, the Army and Department of Defense are assessing whether UXO degrades in the environment. This project will produce models and information that show UXO degradation over time.

**Purpose**

To assess if and how UXO degrades.

**Benefits**

This program will produce a computer model that predicts UXO degradation. The data generated during this program will support Army efforts to assess the environmental impact of UXO.

**Technology Users**

Army installations and the Department of Defense.

**Description**

To assess if and how UXO corrodes, data is being obtained on the factors that influence UXO degradation. Assessments will be made regarding the impact of degraded UXO on the environment.

**Accomplishments and Results**

A preliminary corrosion model was completed in October 1998. A final report, documenting a data search, ordnance groupings, and identification of existing computer models and their limitations, was completed in January 1999.

**Follow-On Program Requirements**

A follow-on effort is underway to include additional "real world" data for the refinement of the preliminary corrosion model.

**Point of Contact**

Tamera Clark

**Program Partners**

U.S. Army Environmental Center
U.S. Army Aberdeen Test Center
U.S. Army Research Laboratory

## UXO Technology Demonstration Program

The Department of Defense needs advanced methods to detect, locate, identify, neutralize, recover and dispose of unexploded ordnance (UXO). The UXO Technology Demonstration Program, conducted at Jefferson Proving Ground, Indiana, has established a framework to better understand and assess UXO technologies.

### Purpose

To evaluate, establish and advance UXO technology performance.

### Benefits

This program has created a framework for the evaluation of UXO technology. Baseline technology performance has been established and technology capabilities and limitations have been assessed. Technology users are better able to select the optimum technology or system for their needs. Private industry has benefited from program feedback and participants are better able to improve their systems.

### Technology Users

Military installations with sites that contain UXO.

### Description

Congress mandated the UXO Technology Demonstration Program. More than 60 technology demonstrations of UXO characterization and remediation technologies have been conducted. Phase I, Phase II and Phase III were conducted in 1994, 1995 and 1996 at Jefferson Proving Ground in Madison, Indiana. The demonstrations were performed on a controlled test site containing a known baseline of emplaced, inert ordnance. Additional technology demonstrations were conducted during 1995 at five sites throughout the United States that contained live ordnance.

For each phase of the demonstration program, companies and government agencies have been given the opportunity to demonstrate their system capabilities. Details of the multiphase demonstration programs are published in reports.

Results of the most recent Phase III demonstrations show that overall technology detection rates have improved since

the initial Phase I demonstration program in 1994. Phase III results show that state-of-the-art technology can detect a substantial portion of emplaced ordnance (over 95%). However, significant technology limitations exist. There has been no substantial change in the ability of demonstrators to discriminate UXO from non-UXO material (known as "clutter"). This deficiency is major cost driver in UXO characterization due to additional data analysis requirements and subsequent unnecessary excavation. Remote excavation of UXO is feasible; the systems were able to locate, excavate and handle the UXO. However, they were slow and inefficient.

The Phase IV effort underway will capitalize on previous UXO technological investments by focusing on target discrimination and reduction of false-alarm rates. This will provide the government with an economical and effective technology able to significantly reduce the cost of UXO clearance (by reducing the number of anomalies that must be excavated).

## Accomplishments and Results

Results from this program have been used across the U.S. to aid in the selection and utilization of companies, systems and sensors for UXO characterization and restoration efforts.

## Limitations

Technology demonstrators are unable to discriminate UXO from non-UXO material (clutter).

## Follow-On-Program Requirements

- Technology enhancements.
- Technology demonstrations.
- Evaluation and reporting.
- Technology transfer.
- Identify support to continue demonstration activities.

## Point of Contact

George Robitaille

## Program Partners

U.S. Army Environmental Center
Naval Explosive Ordnance Disposal Technology Division
U.S. Army Corps of Engineers

## Publications

*Unexploded Ordnance Advanced Technology Demonstration Program at Jefferson Proving Ground (Phase I)*. December 1994.

*Evaluation of Individual Demonstrator Performance at the Unexploded Ordnance Advanced Technology Demonstration Program at Jefferson Proving Ground (Phase I).* March 1995.

*Unexploded Ordnance Advanced Technology Demonstration Program at Jefferson Proving Ground (Phase II)*. June 1996.

*Live Site Unexploded Ordnance Advanced Technology Demonstration Program*. June 1996.

*Unexploded Ordnance Technology Demonstration Program at Jefferson Proving Ground (Phase III).* April 1997.

The Phase IV Report will be available on the USAEC Web site after March 1999.

## Environmentally Redesigned Qualification Training Range for Fort McPherson, Georgia

The soils on many Department of Defense (DoD) small arms ranges contain lead from testing and training activities. Effective design of range areas and impact berms will minimize the potential for off-site migration of lead and reduce maintenance requirements. As a result, these ranges will experience lower maintenance costs, greater availability for training and improved environmental protection.

### Purpose

To design and construct a berm at Fort McPherson's Qualification Training Range that will minimize the environmental impacts of erosion, reduce maintenance requirements and ensure compliance with environmental laws and regulations.

### Benefits

Implementing new berm technologies at Fort McPherson, Georgia, will minimize maintenance requirements and aid in compliance with the Resource Conservation and Recovery Act (RCRA), Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and Clean Water Act.

### Technology Users

DoD installations with small arms ranges.

### Description

Many DoD sites have soils that contain heavy metals due to extensive training on small arms ranges. Numerous facility closures have occurred due to the buildup of lead — a RCRA-listed toxic material — in the soil. To prevent such closures and minimize environmental impacts on Army training and readiness, new technologies are being developed and implemented.

Normal training operations deposit heavy metals from bullets into the soil on small arms ranges. Environmental engineering techniques are necessary to minimize the migration of heavy metals within and away from the range facility. At active sites

such as Fort McPherson's Qualification Training Range, such techniques will prevent pollution and allow the facility to provide effective, realistic training while maintaining high levels of environmental stewardship.

Fort McPherson and the U.S. Army Environmental Center (USAEC), in conjunction with the U.S. Army Training Support Center (ATSC) and the U.S. Army Engineer Research and Development Center-Construction Engineering Research Laboratories (CERL), have implemented innovative environmental technologies on Fort McPherson's Qualification Training Range. The objective of this effort was to provide Fort McPherson with an environmentally sound training range while evaluating the performance of the stabilization technologies for Armywide implementation.

Results from the Environmentally Reengineered Small Arms Range Demonstration at Fort Rucker, Alabama, as well as the latest slope-stabilization technologies, were used to develop the Fort McPherson impact berm design. Design features included:

- Addition of a soil amendment, polyacrylamide (PAM), to achieve optimum engineering potential (i.e., maximum soil adhesion properties);
- Compacting soil to optimum moisture and maximum density and implementing a gabion retaining wall to enable a stable, low-maintenance 45-degree slope in the lower impact area;
- Vegetating the berm with a hearty cover of zoysia grass to minimize the erosional effects of runoff;
- Installing a gutter system to the roof of the Qualification Training Range to direct rainwater away from the impact berm.

## Accomplishments and Results

- The project order was accepted by CERL in FY 1996.
- Designs were coordinated between USAEC, CERL, Fort McPherson, the Combat Training Support Directorate, Deputy Chief of Staff-Training, Training and Doctrine Command, and the U.S. Army Engineering and Support Center, Huntsville.
- Construction was performed by a specified subcontractor under CERL.
- The berm was constructed on schedule.
- The technology performance evaluation period has commenced.

**Limitations**

No "control" cell was used because the initial intention was not to test PAM/different soil types.

**Follow-On Program Requirements**

USAEC will evaluate the performance of the implemented impact berm design for one year. Successful design aspects will be used in future applications. Fort McPherson intends to use lessons learned from this effort to redesign and build a 300-meter impact berm at Fort Gillem, Georgia.

**Point of Contact**

Terri Bright

**Program Partners**

U.S. Army Environmental Center
Fort McPherson, Georgia
U.S. Army Engineer Research and Development Center-Construction Engineering Research Laboratories
Combat Training Support Directorate, Deputy Chief of Staff-Training, Training and Doctrine Command
U.S. Army Engineering and Support Center, Huntsville

## Environmentally Redesigned Small Arms Range Field Demonstration

Numerous Army installations contain firing ranges for small arms training, and many of the ranges have operated since World War II. None of these ranges was designed to facilitate recovery of the lead bullets or prevent lead from leaching into the surrounding environment. This demonstration evaluated range designs and building materials that minimize erosion, lead contamination and other potential environmental effects.

**Purpose**

To evaluate design features to relieve rainwater infiltration and runoff, and evaluate chemical fixing technologies for the capture and recycling of projectiles with minimal contamination of soil.

**Benefits**

Cost-effective combinations of design improvements and soil treatment technologies can reduce lead migration and erosion. Lessons learned at Fort Rucker's South Range will benefit the Army's most environmentally sensitive ranges.

**Technology Users**

Military installations with small arms training ranges.

**Description**

The South Range at Fort Rucker, Alabama, was reconstructed to test several designs for mitigating lead migration. Incorporating bentonite increased slope stability and decreased berm surface erosion. Erosion matting promoted vegetation. Installing end berms and range grading helped to manage stormwater runoff. The addition of a detention pond promoted settling out of lead-contaminated sediment.

**Accomplishments and Results**

Five technology cells were installed in the berm to assess their lead-fixation capabilities, including soil with bentonite (vegetated and unvegetated), MAECTITE chemical treatment, and soil amended with local clay.

Leaching test results indicated that the chemical soil treatments, designed for landfill applications, are inappropriate

for whole-berm applications at most active ranges on which lead concentrates in target pockets.

**Point of Contact**

Mark Hampton

**Program Partners**

U.S. Army Environmental Center
U.S. Army Engineer Research and Development Center-Waterways Experiment Station
Range Division, Fort Rucker, Alabama
Defense Evaluation Support Activity
TRW Systems Integration Group

**Publications**

*Environmentally Redesigned Small Arms Range Demonstration.* SFIM-AEC-ET-CR-97042. September 1997.

## Range Evaluation Software Tool

The Range Evaluation Software Tool and its companion, the Army Sampling and Analysis Plan, are first in a series of initiatives to provide range managers with pollution prevention techniques to mitigate the environmental effects of lead on small arms ranges.

**Purpose**

To provide a tool whereby Army range personnel can evaluate potential hazardous-metal migration on small arms ranges.

**Benefits**

This cost-effective method minimizes full-scale risk assessment and site characterization.

**Technology Users**

Department of Defense installations with small arms ranges.

**Description**

Firing ranges are operated to maintain troop readiness. Many ranges use impact berms as backstops and bullet-trapping devices. The berms are generally semi-engineered piles of soil or modified hillsides. Others use open fields without berms. Projectiles are distributed more uniformly downrange on "bermless" ranges. The projectiles that accumulate in the berms contain several metallic elements of concern, including lead, copper, zinc and antimony.

Some small arms firing ranges have performed preliminary site characterization, but the results have been inconclusive. One problem is locating a single source contributing to lead migration. Firing ranges frequently overlap and are often relocated on an installation. The ubiquitous presence of lead makes it impossible to distinguish between sources.

The Range Evaluation Software Tool (REST) and its companion, the Army Sampling and Analysis Plan (ASAP), are first in a series of initiatives to provide range managers with pollution prevention techniques to mitigate the environmental effects of lead on small arms ranges.

REST works on IBM-compatible personal computers (386 or

higher) running on Windows 3.1 (or higher) operating systems. It estimates potential heavy-metals migration for user-defined "Areas of Concern" based on site characteristics. Its input screens request information related to range use, the range's physical and geological characteristics, geographic location and climate. The REST output provides a four-color, four-level relative ranking association with a numeric range of scores indicating overall migration potential. REST also scores five parameters contributing to the Overall Area Score: (1) Ammunition Mass, (2) Corrosion, (3) Aerial Transport, (4) Surface Water Transport, and (5) Groundwater Transport. These individual transport scores indicate which parameters contribute to the overall score.

ASAP is a preliminary sampling program that quantitatively confirms the lead (or other metal) migration indicated by REST along specific pathways. ASAP presents the basis of the sampling approach for the three modes of metal transport (air, surface water and groundwater) and provides detailed instructions on how, when and where to collect and analyze water and soil samples for each mode of transport. Users may opt to sample all three transport pathways based on the output from REST.

The REST manual provides general instructions for installation and operation. Specific screen-by-screen instructions are provided in the software. The ASAP document covers types, numbers and locations of samples necessary to quantify concentration levels; provides advice regarding the interpretation of sampling results; and identifies characteristics that may be used to find the equipment and services necessary for sampling and analysis.

**Point Of Contact**

Martin Stutz

**Program Partners**

U.S. Army Environmental Center
U.S. Army Training Support Center

**Publications**

*The Range Evaluation Software Tool (REST) and the Army Sampling and Analysis Plan (ASAP) for Small Arms Ranges.* Report Number SFIM-AEC-ET-CR-97037.

## Shock Absorbing Concrete Performance and Recycling Demonstration

Recovering lead and other bullet fragments from conventional soil berms is often difficult. As a result, lead and other heavy metals may leach into groundwater, potentially resulting in a remediation effort. Impact berms constructed from a special type of concrete will retain bullets while providing an easy-to-recycle berm material.

### Purpose

To assess the use of Shock Absorbing Concrete (SACON) to reduce the potential of off-site migration of lead and other heavy metals.

### Benefits

SACON may provide a means to recycle projectiles and prevent buildup of heavy metals in range soils. SACON could also mitigate the excessive soil erosion experienced on outdoor ranges caused by bullet impacts. Erosion control and soil stabilization would help prevent migration of heavy metals off the range, and alleviate the recurring costs of land rehabilitation on the ranges. In addition, SACON may reduce or eliminate safety problems caused by ricochets off natural or other materials.

### Technology Users

The Army — primarily Forces Command (FORSCOM) and Training and Doctrine Command (TRADOC) installations — as well as the National Guard, Navy, Marine Corps, Air Force and Coast Guard.

### Description

Numerous Department of Defense (DoD) small arms ranges contain lead and other metals in soils. In some cases, those inorganic materials may "migrate" to surface water or groundwater. The Army operates approximately 1,400 outdoor small arms ranges in the continental United States (CONUS); the Navy operates approximately 270 outdoor small arms ranges (including Marine ranges) and the Air Force operates approximately 200 outdoor small arms ranges. The U.S. Army Environmental Center (USAEC), U.S. Army Training Support Center (ATSC) and U.S. Army Engineer Research and Development Center-Waterways Experiment Station (WES) seek ways to reduce the potential of off-site migration of lead and other heavy metals.

SACON has been used as a bullet-stopping material since the 1980s. It has been extensively field tested with a variety of small arms, including military and civilian automatic and semi-automatic weapons. The Army and other federal and state agencies have fabricated "training villages" from SACON. However, SACON has not been demonstrated as a berm material on conventional small arms ranges.

SACON can be used to build safe, durable, low-maintenance barriers that can hold spent bullets in a low-permeability, alkaline matrix that will minimize escape of potentially harmful metals into surrounding soil or groundwater. After use, the SACON bullet traps can be recycled. The SACON is crushed and the bullet fragments separated from the crushed material. The aggregate developed from the crushed SACON can be used to recast blocks in a new foamed concrete mixture. The bullet fragments can be recycled.

Two sites have been selected for demonstration of SACON: the U.S. Military Academy (USMA) at West Point, New York; and Fort Knox, Kentucky. Initially, SACON will be tested on 25-meter zero ranges at both sites. Additional tests will be performed on automated record fire (ARF) ranges at both sites and on an automated field fire (AFF) range and a combat pistol qualification course (CPQC) at Fort Knox.

## Limitations

Use of SACON to capture rounds may result in:

- Increased maintenance costs for ranges;
- Increased construction costs for new or refurbished ranges;
- Reduced range use flexibility (SACON must be designed for specific calibers of ammunition).

## Accomplishments and Results

- Preliminary field trials were conducted on the 25-meter ranges at Fort Knox and USMA in November 1996. The SACON blocks were redesigned based on performance data and discussions with range personnel; new blocks were installed on the 25-meter ranges at Fort Knox and USMA in March 1997.
- An initial briefing of the data collection requirements was given to the range managers at USMA and Fort Knox in November 1996.

- The Cooperative Research and Development Agreement between WES and Ballistics Technology International has been signed.
- A manuscript was published in the proceedings of the American Defense Preparedness Association (ADPA) 1997 Waste Management Conference. The paper, presented in January 1997, is titled "Management of Spent Bullets and Bullet Debris on Training Ranges."
- A paper titled "Chemical Containment of Heavy Metals from Bullet Debris in Shock-Absorbing Concrete (SACON) Bullet Barriers" was presented at the 23rd ADPA Environmental Symposium in April 1997.
- A paper titled "Design of Modular Bullet Trapping Units Using Shock Absorbing Concrete (SACON)" was presented at the Tri-Service Environmental Workshop in St. Louis in June 1997.
- SACON was installed on the ARF range at USMA in April 1997. SACON was installed on the ARF, AFF and CPQC at Fort Knox in June 1997. All field demonstrations at USMA and Fort Knox were completed in February 1998.
- A recycling demonstration has been conducted at WES.
- Accelerated durability testing was conducted at the U.S. Army Aberdeen Test Center in March 1998. This was done to fill in data gaps from the field tests at USMA and Fort Knox.

## Follow-On Program Requirements

- Complete the analysis of the field data and issue a final report.
- Disseminate the demonstration results through USAEC's Web site and articles.

## Point of Contact

Gene Fabian

## Program Partners

U.S. Army Environmental Center
Combat Training Support Directorate, Deputy Chief of Staff-Training, Training and Doctrine Command
U.S. Army Engineer Research and Development Center-Waterways Experiment Station
U.S. Military Academy, New York
Fort Knox, Kentucky
Environmental Security Technology Certification Program
U.S. Army Aberdeen Test Center

## Publications

"Management of Spent Bullets and Bullet Debris on Training Ranges." Presentation for the American Defense Preparedness Association (ADPA) 1997 Waste Management Conference.

"Chemical Containment of Heavy Metals from Bullet Debris in Shock Absorbing Concrete (SACON) Bullet Barriers." Paper presented at the 23rd ADPA Environmental Symposium.

"Design of Modular Bullet Trapping Units Using Shock Absorbing Concrete (SACON)." Paper presented at the 1997 Tri-Service Environmental Workshop.

## Small Arms Range Bullet Trap Demonstrations

Lead from bullets fired on small arms ranges may contaminate groundwater and soil. Such lead contamination could lead to range closure and long-term cleanup costs. Capturing the bullets will prevent the lead from entering the environment. The use of bullet traps on small arms ranges will prevent pollution and result in greater range availability for training, long-term savings, and environmental protection.

### Purpose

To reduce the potential of off-site migration of lead and other heavy metals; to reduce the impacts on the environment; and to promote training readiness through pollution prevention methods that reduce environmental compliance impacts.

### Benefits

Bullet traps may provide a means to recycle projectiles and prevent contamination of ranges and the surrounding environment. Bullet traps would also mitigate excessive soil erosion on outdoor ranges caused by the impact of the projectiles. Erosion control and soil stabilization on the ranges would help prevent the off-range migration of heavy-metal contaminants and alleviate the recurring costs of land rehabilitation on ranges.

### Technology Users

Army and Department of Defense (DoD) installations with small arms ranges. There may also be civilian applications.

### Description

The Army operates approximately 1,400 outdoor small arms ranges in the continental United States (CONUS); the Navy operates approximately 270 outdoor small arms ranges (including Marine ranges) and the Air Force operates approximately 200 outdoor small arms ranges.

Future regulatory focus may restrict testing and training activities and force the closure of valuable small arms range facilities unless methods are implemented to capture and recycle projectile material and prevent contamination of the range and the surrounding environment. Bullets from small arms are primarily lead, which is listed as a toxic material

under the federal Resource Conservation and Recovery Act (RCRA). Once in soil, bullets may corrode and the lead may enter groundwater or surface water, resulting in a potential violation of RCRA or other laws. Cleanup of water contaminated with lead is costly and contamination may result in range closures or restricted use.

Bullet traps can reduce the amount of lead and other metal compounds that end up in soil. Use of bullet traps is presently limited to only a handful of military installations and primarily confined to indoor ranges. This project will identify and test the best available configurations of bullet traps for use at outdoor military ranges.

Techniques that limit the volume of soil containing heavy metals at small arms ranges also will limit cleanup costs and prevent regulatory restrictions of testing and training activities at active sites. Bullet traps that capture and contain projectiles for recycling will limit or possibly prevent soil contamination on training sites.

## Accomplishments and Results

Accelerated testing has been completed on three commercially available bullet traps. The following types of traps were tested in a 25-meter range backstop scenario: composite rubber block trap; granular (or shredded) rubber trap; and steel decelerator type trap.

The consensus is that the bullet traps do not live up to their manufacturers' performance claims. Problems ranged from ill-defined usage limitations to lead-dust containment and exposure concerns. A report documenting the traps' performance, environmental benefits and cost analyses is being written.

## Limitations

Use of bullet traps to capture lead may result in:

- Increased maintenance costs for ranges;
- Increased construction costs for new or refurbished ranges;
- Reduced training realism (in some cases);
- Reduced range use flexibility (some bullets or weapons might damage the traps);
- Increased environmental and personnel exposure risks (if the selected trap is not suited for the type of ammunition used on the range).

**Follow-On Program Requirements**

Complete the bullet trap demonstration report and publicize the demonstration results through the U.S. Army Environmental Center's Web site and articles.

**Point of Contact**

Gene Fabian

**Program Partners**

U.S. Army Environmental Center
U.S. Army Training Support Center
U.S. Army Aberdeen Test Center

**Publications**

*Final Report, Bullet Trap Feasibility Assessment and Implementation Plan, Technology Identification Report.* Report Number SFIM-AEC-ET-CR-96005. March 1996.

*Final Report, Bullet Trap Feasibility Assessment and Implementation Plan, Evaluation Criteria Report.* Report Number SFIM-AEC-ET-CR-96142. April 1996.

*Final Report, Bullet Trap Feasibility Assessment.* Report Number SFIM-AEC-ET-CR-96195. December 1996.

*Final Report, Bullet Trap User's Guide.* Report Number SFIM-AEC-ET-CR-96201.December 1996.

# Small Arms Range Management Manual

Maintenance of small arms ranges must be conducted in ways that protect the environment and comply with environmental regulations. No standard procedures exist for range managers to conduct environmentally proactive maintenance activities. The *Small Arms Range Management Manual* provides a reference and planning tool for training-range management, and presents techniques that will help minimize downtime for ranges and maximize training opportunities for soldiers.

**Purpose**

To develop an operation and maintenance manual for small arms range managers that includes effective ways to reduce the impact of environmental regulations on training.

**Benefits**

Successful standard operating procedures — combined with technologies being developed by the Department of Defense (DoD) — will provide range managers with the tools necessary to maintain compliance without adverse impacts to readiness.

**Technology Users**

DoD and Army range managers.

**Description**

Numerous DoD installations contain small arms ranges that may be susceptible to heavy-metal migration and accelerated erosion rates. A Worldwide Environmental Range Strategy has been devised through the combined efforts of the U.S. Army Training Support Center and the U.S. Army Environmental Center (USAEC) to minimize environmental impacts from range activities while reducing compliance impacts on the training mission. Information in the *Small Arms Range Management Manual* is based on USAEC research and demonstration projects, scientific literature and studies from the Army, Navy, Department of Agriculture and private institutions.

Army ranges are sited according to Chapter 4 of Training Circular (TC) 25-8, Training Ranges. Certain site characteristics (such as physical, geochemical, hydrogeological and climatological) may increase the risk of heavy-metal migration into groundwater, surface water and vegetation. In addition, the buildup of rounds

and fragments results in accelerated erosion rates. Such buildup in berms or backstops could contribute to migration of heavy metals into surrounding soil, groundwater and surface water. Preventive measures are being sought to maintain compliance with the Resource Conservation and Recovery Act (RCRA), Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Clean Water Act (CWA), and to reduce the need for costly cleanup operations.

All relevant information regarding the operation and maintenance of small arms ranges was compiled and incorporated into the manual. The information will assist in the ranges' operation and maintenance efforts to reduce the spread of heavy metals, comply with all laws and regulations, and demonstrate a proactive approach to environmental stewardship.

## Accomplishments and Results

The *Small Arms Range Management Manual* was ready for Armywide distribution in July 1998. The manual is available electronically on the USAEC World Wide Web site.

## Limitations

This manual may contain data insufficient for adequate use by all installation range managers.

## Follow-On Program Requirements

The manual may be modified and incorporated into Chapter 4 of TC 25-8. Updates to the manual will be available on the Web.

## Point of Contact

Terri Bright

## Program Partners

U.S. Army Environmental Center
U.S. Army Training Support Center
Combat Training Support Directorate, Deputy Chief of Staff-Training, Training and Doctrine Command
U.S. Army Engineer Research and Development Center-Waterways Experiment Station
U.S. Army Engineering and Support Center, Huntsville
Major command and installation range managers

## Dust Control Guidance and Technology Selection Key

Military activities generate dust that constrains training, impedes the mission, creates safety problems, damages equipment, contributes to soil erosion, and may violate environmental laws such as the Clean Air Act. The technology to help installations curb this problem exists, but guidance on the identification, selection and application of installation-specific dust control measures has been difficult to find.

### Purpose

To assist Army installation land managers in identifying, selecting and applying the best tools, techniques and products for dust control on tank trails, roads, landing strips and helipads.

### Benefits

Users can take the selection key brochure to the field and sort their options as they assess a site's conditions. The key matches site information – such as climate, soil type, surface characteristics, and the types and number of vehicles that use it – with appropriate and cost-effective dust control strategies.

### Technology Users

Army installation land managers.

### Description

The *Dust Control Guidance and Technology Selection Key* comes in two compatible formats: a brochure and an interactive computer program. The Web-based computer program includes a comprehensive handbook that users can consult for answers to questions that come up in the field.

The handbook includes ways to identify areas that need dust control, as well as explanations of site maintenance, construction methods, and mechanical stabilization practices to consider before using dust control products. It also provides references pertaining to dust control programs used by other federal and state agencies, and a flow chart for quick reference.

**Accomplishments and Results**

The selection key is in its final review. It has been field-demonstrated at Forts Pickett, Stewart and Leonard Wood, and the Orchard Training Area in Idaho. The demonstrations were completed in November 1998.

**Limitations**

The key is specifically designed for controlling dust on roadways, trails and aircraft landing zones. This document is not all-inclusive. The U.S. Army Environmental Center does not endorse any commercial products listed in the document.

**Follow-On Program Requirements**

Demonstration comments will be incorporated into the selection key. The inclusion of wheeled and tracked vehicle testing of each product type in the document has been suggested by the major commands; this inclusion will depend on available funding.

**Point of Contact**

Kim Michaels

**Program Partners**

U.S. Army Environmental Center
U.S. Army Engineering Research and Development Center
U.S. Army Training and Doctrine Command
U.S. Army Forces Command
National Guard Bureau
Fort Pickett, Virginia
Fort Stewart, Georgia
Fort Leonard Wood, Missouri
Orchard Training Area, Idaho

**Publications**

The final document will be published in April 1999.

## ◀ Land-Based Carrying Capacity

The Army's primary missions are to train soldiers and test weapons and defense systems. Trainers and land managers realize that training and testing areas must be realistic, ecologically healthy and ready for long-term use. Land-Based Carrying Capacity (LBCC) technologies will help installations estimate current and predict future land-condition status, and establish a relationship between training load and land condition.

### Purpose

To demonstrate and validate four products that apply directly to the improvement of the environmental component of the Army Training and Testing Area Carrying Capacity (ATTACC) model. These products could also serve as stand-alone tools for natural resources and land management activities.

### Benefits

LBCC technologies will help installations estimate current and predict future land-condition status, and establish a relationship between training load and land condition.

### Technology Users

Army trainers, land managers and natural resource managers.

### Description

Installation land and natural resource managers need efficient tools, models and techniques to characterize, integrate constraints on, and quantify the capability of land and natural resources to support military training and testing missions. Installation training managers need to identify carrying capacity of training lands, predict the impacts of land-based usage, understand risk associated with use, and analyze decisions to provide training flexibility versus environmental or ecological damage.

The C Factor, LS Factor and distribution modeling demonstration validation studies will be conducted at Fort Hood, Texas. The EDYS demonstration validation effort will be conducted at Fort Bliss, Texas, and Fort Hood.

Four products will be demonstrated and validated:

- Improvement to the Revised Universal Soil Loss Equation (RUSLE), specifically an improved slope length and steepness factor (LS Factor) based on the unit stream power theory and upslope contributing area;
- Improvement to the RUSLE, specifically the use of a vegetation-index-derived method for extrapolating the "C Factor" (cover factor) measured at Land Condition Trend Analysis (LCTA) sites;
- A Community Dynamics Simulation (EDYS) model that predicts changes in plant species composition over time and in response to natural and anthropogenic disturbances;
- A training distribution model that utilizes spatial terrain characteristics to predict the pattern and intensity of the training load over the landscape.

## Accomplishments and Results

Fort Hood, Fort Bliss, the U.S. Army Environmental Center (USAEC) and the U.S. Army Engineering Research and Development Center met to plan the project. The project was well received and has been implemented successfully at both demonstration installations.

## Limitations

The four products must be approved individually by the ATTACC governing body. It should not be automatically assumed that these products will be incorporated into ATTACC until authorization is given.

## Follow-On Program Requirements

This project covers only the first phase of the EDYS demonstration.

## Point of Contact

Kim Michaels

## Program Partners

U.S. Army Environmental Center
U.S. Army Engineering Research and Development Center
Fort Hood, Texas
Fort Bliss, Texas
U.S. Army Training and Doctrine Command
U.S. Army Forces Command
U.S. Army Training Support Center

## Tactical Concealment Area Planning and Design Guidance Document

Installation trainers and environmental resource managers need tools to help them combat the problems of training-site degradation and rehabilitation. The U.S. Army Environmental Center and U.S. Army Engineering Research and Development Center have developed a planning and design tool to help trainers and land managers enhance installation training resources using suitable development techniques for improving wildlife habitat, environmental-resource protection and soldier safety.

### Purpose

To demonstrate the applicability, usefulness and viability of an installation-based Tactical Concealment Area (TCA) guidance document.

### Benefits

The project will produce an approach to training land design that realizes a systematic integration of training and environmental requirements to enhance and expand an installation's training resources. The technology will help create realistic training areas, protect natural and cultural resources, and enhance environmental stability. This document will give installations the opportunity to create and integrate tactical concealment into total training area design. The document will also provide guidance that allows the installation to complete work in-house rather than by contract.

### Technology Users

Army trainers, and installation natural and cultural resources managers.

### Description

The development and use of well-designed tactical concealment enhances training realism and effectiveness by providing cover in a tactical training environment. The added benefit of isolating potentially hazardous areas and protecting sensitive areas from training activities suggests that tactical concealment needs to be carefully designed and integrated into the total training area design and the environment to optimize effectiveness and overall environmental stability.

The first tactical concealment design in the United States was implemented at Fort Riley, Kansas. The design constructed was a cluster of horseshoe-shaped islands. Subsequent tactical concealment areas at other installations followed the Fort Riley design with slight modifications. Recent observations of the designs' military use indicate flaws; efforts are underway to evaluate these flaws and eliminate them from planning and design of new tactical concealment areas.

The TCA guidance document is a holistic approach that considers an installation's training needs, existing resources and environmental constraints in planning and designing realistic training areas. The result is greater safety, less equipment damage, fewer environmental impacts, and enhanced training realism. The TCA guidance document details how to integrate both training and environmental considerations into the planning process and how to effectively implement the design. The guidance document gives installations the opportunity to complete work in-house instead of through contractors, saving money and affording installations more control over their projects.

## Accomplishments and Results

The TCA guidance document is being field-tested at several demonstration sites: Camp Bullis, Texas; Fort Hood, Texas; Camp Guernsey, Wyoming; and Camp Ripley, Minnesota. The demonstrations will prove the utility and applicability of the guidance document at Army installations. Direct user input from the demonstration sites (as well as comments from other installations and major commands) is being integrated into the document.

This project was well received when briefed at the FY 1996 Army Integrated Training Area Management (ITAM) Workshop and the FY 1997 National Guard ITAM Workshop. Two National Guard sites — Camp Guernsey and Camp Ripley — joined the project in June 1997. Demonstration results were briefed at both FY 1998 ITAM workshops.

## Limitations

This document is not a complete answer to solving all training area management problems; it is a guide for installations that need assistance.

**Follow-On Program Requirements**

Installation monitoring will take place past the "project complete" stage. It may be necessary for installations to complete site modifications to better service their training missions.

**Point of Contact**

Kim Michaels

**Program Partners**

U.S. Army Environmental Center
U.S. Army Engineering Research and Development Center
U.S. Army Training Support Center
U.S. Army Training and Doctrine Command
U.S. Army Forces Command
National Guard Bureau
Fort Hood, Texas
Camp Bullis, Texas
Camp Guernsey, Wyoming
Camp Ripley, Minnesota

**Publications**

The final guidance document will be published in April 1999.

## Vegetation Wear Tolerance

Erosion can affect the quality of training sites and the environment on Army installations. Revegetating eroded areas with species able to tolerate heavy vehicle and troop traffic will reduce erosion, keep lands open for training and maneuvers, and save time and money.

### Purpose

To determine which vegetative species are the most tolerant to wear from troop and vehicle traffic on individual installations within a climatic region.

### Benefits

Revegetating eroded areas with species able to tolerate heavy vehicle and troop traffic will reduce erosion, keep lands open to training and maneuvers, and save time and funds.

### Technology Users

Installation range and natural resource managers.

### Description

Demonstrations using vegetation thought to best reclaim eroding land and withstand wear from troops and vehicles will be conducted at three installations within a regional climatic area, on two or three dominant soil types.

After selecting the region and installation for the initial demonstration, researchers will select best-known species for use by installation and climatic region (including soils). They will design a test and demonstration project that can be used at all sites for statistical analysis and evaluation. They will then select specific sites on the installations and begin the demonstration.

The demonstrations will be monitored for about three to four years. The demonstrations will have controlled troop and vehicle traffic, submitting the plants to diverse levels of wear. Based on the test results, certain species will be recommended for installation and regional use. The species may be installation-specific to one or more soils, or may be adaptable to all installations and soils within the climatic region. Information on these species will be added to the

VegSpec computer program so natural resource and range managers can easily identify and select the plants best suited for their revegetation needs.

This demonstration is being conducted in cooperation with the Natural Resources Conservation Service (NRCS).

## Accomplishments and Results

Limited funding reduced the demonstration to one installation. Fort Leonard Wood, Missouri, was chosen as the best site, due to the installation's interest in the project and its capability to handle all levels of the demonstration.

Five sites on Fort Leonard Wood were selected for the demonstration:

- Disturbed upland lawn, sunny and droughty, with intense foot traffic;
- Disturbed upland lawn, sunny and droughty, with intense tire and track traffic;
- Disturbed bottomland, sunny and droughty, with intense tire and track traffic;
- Wooded upland, sunny and droughty, with intense foot traffic;
- Disturbed upland, sunny and droughty, with tire traffic and small arms damage.

Vegetation was selected and established on the individual sites considered able to withstand heavy foot, tire and/or track traffic. The vegetation will be given a year to establish, and controlled traffic sequences will begin in 1999 to determine the durability of the different selections.

## Follow-On Program Requirements

- Review installations and select demonstration sites.
- Initiate project on all sites by preparing them for planting.
- Plant projects on all installations.
- Review all sites for stands and replant if necessary.
- Monitor project; make sure vehicle and foot traffic is applied according to the project plan.
- Record results, summarize data, prepare technical report and publish results.

## Point of Contact

David Lorenz

**Program Partners**

U.S. Army Environmental Center
Natural Resources Conservation Service
Fort Leonard Wood, Missouri

## Ordnance Emissions Test Program

Military installations need to characterize the emissions generated by munitions during training and testing activities. The Ordnance Emissions Test Program will provide the Army and Defense Department with data to help them assess the environmental impacts from munitions use, as well as build various models and health and risk assessments.

**Purpose**

To obtain data and identify models that quantify the emissions generated from smoke and pyrotechnic items containing explosives or other energetic fills.

**Benefits**

The data generated from this effort will help the Army assess the environmental impacts of using munitions during training and testing operations. The emissions data can be used to feed various models (such as air, fate and transport) and support the generation of health and risk assessments. Installations can also use the data to meet Emergency Planning and Community Right-to-Know Act (EPCRA) or the Toxic Release Inventory (TRI) reporting requirements.

**Technology Users**

Army and Department of Defense installations.

**Description**

Efforts have been made to document and assess existing data, identify applicable models, and develop test matrices and methodologies relative to characterizing emissions generated by Army munitions. Testing of numerous items will provide "real world" emissions data.

**Accomplishments and Results**

Testing on 19 items has been conducted at Dugway Proving Ground, Utah,. to gather emissions data on smoke and pyrotechnic items.

**Follow-On Program Requirements**

Additional item testing will be conducted at Dugway Proving Ground and the U.S. Army Aberdeen Test Center.

**Point of Contact**

Tamera Clark

**Program Partners**

U.S. Army Environmental Center
U.S. Army Aberdeen Test Center
Dugway Proving Ground, Utah

# VI PROGRAM FOCUS: SCAPS

The Site Characterization and Analysis Penetrometer System (SCAPS) program is a tri-service initiative to develop, demonstrate and transition tools that rapidly characterize subsurface contamination.

SCAPS features a truck-mounted cone penetrometer. Attached to the penetrometer is one of several sensor probes, which relays information on subsurface contaminants to the surface for immediate analysis and interpretation. SCAPS provides the ability to collect and analyze field data faster than traditional methods. It costs less than conventional sampling techniques, so researchers can collect more samples in a shorter time and quickly define a site's contamination boundaries. SCAPS produces fewer investigation-derived wastes than traditional site-characterization tools. SCAPS also can delineate the extent of subsurface contamination more accurately and for less money than widely spaced monitoring wells.

SCAPS has been used on Army, Navy, Air Force, Department of Energy (DOE) and Environmental Protection Agency (EPA) sites.

The U.S. Army Environmental Center is the lead organization responsible for SCAPS project management and coordination with the appropriate regulatory agencies and potential government and commercial users. The U.S. Army Engineer Research and Development Center-Waterways Experiment Station (WES) conducts the field demonstrations. WES and Oak Ridge National Laboratory cooperatively perform data analysis and laboratory verification, and document the results in published reports and technical papers. More information is available on the USAEC Web site at aec-www.apgea.army.mil:8080/ (click on "Technology," then on "SCAPS").

## SCAPS Sensors/Samplers

At the heart of the Site Characterization and Analysis Penetrometer System (SCAPS) are the sensor probes, which provide the capability to identify and quantify underground contaminants. Sensors exist that can detect and quantify heavy metals, explosives, volatile organic compounds (VOCs), and petroleum, oils and lubricants (POLs).

### Purpose

To develop sensor packages that enhance SCAPS capability as an effective Department of Defense (DoD) tool.

### Benefits

SCAPS sensors will reduce costs and speed the decision process regarding site cleanup.

### Technology Users

Army, Navy and Air Force restoration organizations, the Department of Energy (DOE), the Environmental Protection Agency (EPA).

### Description

SCAPS is a proven, effective tool for rapid site characterization and assessment. Because it pushes a penetrometer into the soil rather than drilling a hole, it is quicker, less expensive and generates less waste that traditional site characterization technologies. SCAPS sensors to detect and quantify four contaminants — heavy metals, volatile organic compounds (VOCs), petroleum, oils and lubricants (POLs) and explosives — are available.

***Heavy Metals***
**X-Ray Fluorescence** – The SCAPS X-Ray Fluorescence sensor detects and quantifies heavy metals in soils. This proven method uses an x-ray source to cause metals to emit unique fluorescence x-rays, which are analyzed on the surface. The X-Ray Fluorescence (XRF) sensor can operate above or below the water table.

**Laser Induced Breakdown Spectroscopy** – The Laser Induced Breakdown Spectroscopy (LIBS) quantifies metal concentrations by creating laser-induced plasma. Emissions

from the plasma are carried to the surface for spectrographic analysis. Test results indicate that the probe design can provide in-situ detection of metals in soils down to parts per million (ppm).

*Volatile Organic Compounds*

**HydroSparge VOC Sensor Probe** – A Hydropunch is pushed into the ground to create a temporary monitoring well that provides access to groundwater. An in-situ, direct sparge sampler device developed by Oak Ridge National Laboratory (ORNL) strips VOCs from the groundwater and returns them to the surface for real-time, on-site analysis by an ion trap mass spectrometer (ITMS).

**Thermal Desorption VOC Sampler** – The SCAPS probe pushes the sensor to the desired depth and a known volume of soil is collected in a sample chamber. Heat is applied and contaminant vapors are purged, transported to the surface, trapped, desorbed, and analyzed in real-time by an ITMS. The sample is expelled, the probe pushed to a new depth and the process repeated.

*Petroleum, Oils and Lubricants*

**Laser Induced Fluorescence (LIF) Probe** – This patented sensor uses ultraviolet laser energy to induce fluorescence in POL contaminants present in subsurface soils. Through a fiber optic cable link, fluorescent energy (which indicates POL contamination) is returned to the surface for real-time spectral data acquisition and processing.

*Explosives*

**Explosives Sensor** – The SCAPS explosives sensor detects explosives contamination by heating soil samples to generate nitric oxides, which are detected by an electrochemical sensor inside the probe.

Detailed field tests and demonstrations have provided direct comparisons between the SCAPS explosives sensor and standard methods that include laboratory and field analyses of physical samples.

## Accomplishments and Results

***Heavy Metals***

- Two successful field tests completed for all probe configurations at Joliet Army Ammunition Plant, Illinois, and Lake City Army Ammunition Plant, Missouri.
- Continued field testing planned at North Island Naval Air Station, California.

***Volatile Organic Compounds***

*Thermal Desorption Sampler and HydroSparge Sensor*

- Conducted a field test at Building 525, Aberdeen Proving Ground (APG), Maryland.
- Conducted a field test at the U.S. Army Engineer Research and Development Center-Cold Regions Research and Engineering Laboratory (CRREL).
- Conducted a demonstration at Bush River Area, APG.
- Conducted a demonstration at McClellan Air Force Base, California.
- Demonstrations and pursuit of regulatory acceptance funded by the Environmental Security Technology Certification Program (ESTCP).
- A German demonstration was performed in conjunction with the U.S./Germany data exchange program.
- Completed a field effort at CRREL.
- Completed a field effort at Fort Dix, New Jersey.
- Completed a field effort at Yuma Proving Ground, Arizona.
- Completed a field effort at North Island Naval Air Station.
- Completed a field effort at Longhorn Army Ammunition Plant, Texas.
- Completed a field effort at Vance Air Force Base, Oklahoma (trained Tulsa District).

***Petroleum, Oils and Lubricants***

- The POL sensor technology has been patented and licensed for commercial production and marketing. It is a standard Corps of Engineers district tool
- The POL sensor technology has been demonstrated in Germany and is characterizing sites throughout Europe.

*Explosives*

- Field tests conducted at Volunteer (Tennessee), Longhorn and Joliet Army Ammunition Plants.
- Field test conducted at Pantex (Department of Energy site).
- Transitioned system to U.S. Army Corps of Engineers districts.

**Other results:**

- SCAPS has been evaluated under the EPA Superfund Innovative Technology Evaluation (SITE) program. Phase 2 technology validation under the EPA-led Consortium for Site Characterization Technology (CSCT) was completed in the first quarter of FY 1996.
- Formalized coordination of SCAPS sensor development efforts among DoD, DOE and EPA.
- The Army has transitioned three SCAPS trucks to the U.S. Army Corps of Engineers to characterize Army and Air Force sites. The Navy operates two trucks to characterize its sites.
- California has certified the LIF technology. Reciprocity with other states is being pursued through the Interstate Technology Regulatory Cooperation Workgroup (ITRC).

## Limitations

SCAPS can only be used in areas where a cone penetrometer probe can penetrate stratigraphy.

## Follow-On Program Requirements

*Heavy Metals*

- Conduct third field investigation for ESTCP.
- Letter report of findings.
- Select demonstration and validation sites.
- Complete demonstration plan.
- Complete application to Cal/Cert.
- Complete Cal/Cert with ITRC.
- Transition to Army/Navy SCAPS.
- License technologies.

*Volatile Organic Compounds*

- Complete verification analysis.
- Generate final report.
- Certification with California is pending for the VOC sensors, as well as reciprocity with other states through the ITRC.

*Explosives*

- Suggest change of direction to ESTCP.

## Point of Contact

George Robitaille

## Program Partners

U.S. Army
U.S. Navy
U.S. Air Force
U.S. Department of Energy
U.S. Environmental Protection Agency

## Publications


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*Numerous SCAPS papers were presented at the 1997 EPA Air and Waste Management International Symposium on Field Screening Methods for Hazardous and Toxic Waste in Las Vegas, Nevada. Those presented included TDS and HydroSparge, explosives, metals and POL sensors. Publications from the proceedings include:*

Robitaille, G. and M. Ruddle. "SCAPS Characterization of VOC Contaminated Sites." *Field Analytical Methods for Hazardous Wastes and Toxic Chemicals*, Air and Waste Management Association. Pittsburgh, Pennsylvania. VIP-71, 443-452.

Davis, W.M., J.F. Powell, K. Konecny, J. Furey, C.V. Thompson, M. Wise, and G.E. Robitaille. "Rapid In-Situ Determination of Volatile Organic Contaminants in Groundwater Using the Site Characterization and Analysis Penetrometer System." *Field Analytical Methods for Hazardous Wastes and Toxic Chemicals.* Air and Waste Management Association. Pittsburgh, Pennsylvania. VIP-71, 464-469.

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McGinnis, W.C., S.H. Lieberman, and D.S. Knowles. "A Case Study of Field Screening for POL Contaminants Using the SCAPS LIF Cone Penetrometer System." *Field Analytical Methods for Hazardous Wastes and Toxic Chemicals.* Air and Waste Management Association. Pittsburgh, Pennsylvania. VIP-71, 453-463.

## Tri-Service SCAPS Pursuit of Regulatory Acceptance

The Tri-Service Site Characterization and Analysis Penetrometer System (SCAPS) has been proven as an effective tool for rapid site characterization and assessment. Sensors to detect and quantify four classes of contaminants are currently available. Several of these sensors have been demonstrated to state and federal regulators for approval as part of a comprehensive validation program.

**Purpose**

To attain state and federal regulatory acceptance, as well as commercial acceptance, for new SCAPS sensor technologies.

**Benefits**

Reduced cost, sampling and time needed to characterize contamination of a site in comparison to traditional methods.

**Technology Users**

Government facilities and private industry.

**Description**

The pursuit of regulatory acceptance began with the Laser Induced Fluorescence (LIF) sensor in the Environmental Protection Agency (EPA) Superfund Innovative Technology Evaluation (SITE) program. From there, the LIF entered the EPA Consortium for Site Characterization Technology (CSCT) and Interstate Technology Regulatory Cooperation Workgroup (ITRC), formerly the WGA-ITRC. A standard practice for the American Society of Testing and Materials (ASTM) for the LIF has been accepted and given the designation D-6187-97. The HydroSparge Sensor (HS) and Thermal Desorption Sampler (TDS) have been initiated into the process of certification with the Cal/Cert program and the ITRC. Both the HS and TDS will follow in the path of the LIF in pursuit of an ASTM method.

Regulatory acceptance for the HS and TDS is being sought on state and federal levels, as well as in the private sector. The technologies have been submitted for certification with Cal/Cert and ITRC on state and federal levels. Commercially, the technologies will be submitted as ASTM methods, and a strong interest in licensing has been expressed.

## Accomplishments and Results

*ASTM – Laser Induced Fluorescence Sensor*

- Submitted draft document to subcommittee chairman for ballot in September 1996.
- Met with subgroup concerning ballot of method at ASTM conference in January 1997.
- Balloted concurrently at subcommittee level and main committee level.
- LIF accepted and given designation D-6187-97.

*Cal/Cert — HydroSparge Sensor*

- Conducted a field test at Building 525, Aberdeen Proving Ground (APG), Maryland.
- Conducted a field test at the U.S. Army Engineer Research and Development Center-Cold Regions Research and Engineering Laboratory (CRREL).
- Conducted a demonstration at Bush River Area, APG.
- Conducted a demonstration at McClellan Air Force Base, California.
- Completed a field effort at Vance Air Force Base, Oklahoma.
- Completed a field effort at Yuma Proving Ground, Arizona.
- Completed a field effort at North Island Naval Air Station, California.
- Completed a field effort at Longhorn Army Ammunition Plant, Texas.
- Accepted by the ITRC subgroup to assist in implementing state reciprocity by endorsing the Cal/Cert process.
- Demonstrations and pursuit of regulatory acceptance funded by the Environmental Security Technology Certification Program (ESTCP).
- Evaluation of provisional SW846 method 8265 by the EPA Office of Hazardous Waste.

*Cal/Cert — Thermal Desorption Sampler*

- Conducted a field test at Building 525, APG.
- Conducted a field test at CRREL.
- Conducted a demonstration at Bush River Area, APG.
- Conducted a demonstration at McClellan Air Force Base.
- Conducted a demonstration at CRREL.
- Completed a field effort at Joliet Army Ammunition Plant, Illinois.
- Completed a field effort at Lake City Army Ammunition Plant, Missouri.

- Completed a field effort at Longhorn Army Ammunition Plant.
- Demonstrations and pursuit of regulatory acceptance funded by ESTCP.
- Evaluation of provisional SW846 method 8265 by the EPA Office of Hazardous Waste.
- Accepted by the ITRC subgroup to assist in implementing state reciprocity by endorsing the Cal/Cert process.

***ITRC — HydroSparge Sensor***

- Accepted by ITRC subgroup to assist in implementing state reciprocity by endorsing the Cal/Cert process.
- Conducted a Visitors Day at McClellan Air Force Base.
- Distributed the McClellan data package.
- Distributed Method 8265 (provisional) for review.
- Invitational orders mailed for Fort Dix demonstration.
- Conducted a workshop at ITRC training meeting.
- Conducted a demonstration at Fort Dix, New Jersey.

***ITRC — Thermal Desorption Sampler***

- Accepted by ITRC subgroup to assist in implementing state reciprocity by endorsing the Cal/Cert process.
- Conducted a Visitors Day at McClellan Air Force Base.
- Conducted a workshop at ITRC training meeting.

## Limitations

ASTM is a slow process dependent on feedback from an extensive review. There may not be sufficient funding to continue the ASTM effort.

It is not clear whether SCAPS technologies will have a dedicated ITRC subgroup in the future. Cal/Cert is an expensive endeavor; future funding is uncertain.

## Follow-On Program Requirements

***ASTM***

- Initiate HS practice.
- Submit methods to subcommittee chairman.

***Cal/Cert — HydroSparge Sensor***

- Review all data packages.
- Certification pending.

*Cal/Cert — Thermal Desorption Sampler*

- Prepare all data packages.
- Review all data packages.

*ITRC — HydroSparge Sensor*

- Attend ITRC meetings.
- Maintain interactions with Cal/Cert activities.
- Final report for SCAPS sub-team and acceptance of all members pending.

*ITRC — Thermal Desorption Sampler*

- Attend ITRC meetings.
- Maintain interactions with Cal/Cert activities.
- Final report for SCAPS sub-team and acceptance of all members pending.

## Point of Contact

George Robitaille

## Publications

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Brown, G., and B. Filbert. "APG, AEC demonstrate effort that saves money, helps environment." *APG News*. August 28, 1996: p. 10.

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“Multi-State Evaluation of the Site Characterization and Analysis Penetrometer System – Volatile Organic Compounds (SCAPS-VOC) Sensing Technologies.” ITRC Technical/Regulatory Guidelines ASC-4. February 1998.

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Lieberman, S.H. “Direct Push, Fluorescence-Based Sensor Systems for In Situ Measurement of Petroleum Hydrocarbons in Soils.” *Field Analytical Chemistry and Technology*, 2(2), 1998: p. 63-74.

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Bujewski, G. and B. Rutherford. "The Site Characterization and Analysis Penetrometer System (SCAPS) Laser-Induced Fluorescence (LIF) Sensor and Support System: Innovative Technology Verification Report." Report EPA/600/R-97/019. U.S. Environmental Protection Agency. Las Vegas, Nevada. 1997.

## TRI-SERVICE ENVIRONMENTAL TECHNOLOGY WORKSHOP

In this age of decreasing funds, it is important for the military services to leverage available resources and information. The Tri-Service Environmental Technology Workshop provides such an opportunity. The workshop is a forum for technical exchange and interaction on environmental technology strategies, initiatives, demonstrations and products.

**PURPOSE**

To provide a forum for technical exchange and interaction on environmental technology strategies, initiatives, demonstrations and products.

**BENEFITS**

By combining efforts with the Navy and Air Force, the Army reduces its funding needs to one-third of the workshop's total cost. The workshop also helps disseminate information across the services, reducing the "reinventing the wheel" syndrome. Combining what could be three conferences into one also reduces personnel travel expenses and time away from the office.

**TECHNOLOGY USERS**

Department of Defense installations.

**DESCRIPTION**

In 1995, the U.S. Army Environmental Center (USAEC) hosted the Department of Defense Environmental Technology Workshop. Bringing together the three military environmental support centers, this venue offered the opportunity for a unified position on environmental technology. The need to share information was recognized by the services. Since then, the services have supported and USAEC has hosted the annual Tri-Service Environmental Technology Workshop.

USAEC remains the host agency for the workshop and chair of the organizational committee. The organizational committee includes an individual from each service's environmental support center and an individual from each

service's Environment, Safety and Occupational Health office. The committee's main role is to review and select abstracts for platform presentation; it performs other functions as necessary. The balance of the effort is handled by USAEC and the support contractor, Science and Technology Corporation.

Workshop presentations focus on mature technologies that are of timely interest to participants. Emphasis is placed on technologies that are "field ready," are currently being demonstrated, or have been demonstrated. This workshop is supported by the Tri-Service Environmental Support Centers Coordinating Committee.

## Accomplishments and Results

The 1998 Tri-Service Environmental Technology Workshop, held August 18-20 in San Diego, California, was well attended, despite an overall reduction in travel funds for government employees and contractors. It included 33 exhibitors and 64 technical presentations. The plenary session included presentations from USAEC, the Director, Directorate of Research and Development for the Army, the Air Force Center for Environmental Excellence, and the Naval Facilities Engineering Service Center. A tour of several Navy Environmental Leadership Projects/Sites at the Naval Air Station, North Island, was offered to attendees.

## Follow-On Program Requirements

- The 1998 proceedings will be received from the contractor and made available on the USAEC Web site.
- Members of the organization committee will conduct discussions on the next Tri-Service Environmental Technology Workshop, tentatively scheduled for 2000.

## Point of Contact

Darlene F. Bader

## Program Partners

U.S. Army Environmental Center
Office of the Director of Environmental Programs
Office of the Assistant Secretary of the Navy for Installations and Environment
Headquarters, Air Force
Naval Facilities Engineering Service Center
Air Force Center for Environmental Excellence

**PUBLICATIONS**

Report Number SFIM-AEC-ET-CR-96187 (Proceedings from 1996 workshop).

Report Number SFIM-AEC-ET-CR-9705 (Proceedings from 1997 workshop).

## U.S. Army Environmental (User) Requirements and Technology Assessments Process and Web Site

During the first 15 years of Army environmental research, most Research, Development, Test and Evaluation (RDT&E) goals and objectives were established through informal coordination within the Army development community. Given greater emphasis on relevance to Army users, a more rigorous, requirements-based approach was developed in the early 1990s. Since 1993, the environmental user requirements process has been formalized into a two-year cycle aligned with the Program Objective Memorandum process.

### Purpose

To serve as Army Headquarters' central repository for environmental user requirements; to present the Army's validated and prioritized environmental user requirements to help the RDT&E community identify opportunities for developing and demonstrating improved environmental systems; and to identify applicable off-the-shelf technologies to help Army users make informed decisions on technologies that are better, faster and more cost-effective.

### Benefits

In addition to satisfying the annual Department of Defense (DoD) tri-service reporting requirement to the Environmental Security Technology Requirements Group (ESTRG), the U.S. Army Environmental (User) Requirements and Technology Assessments (AERTA) process enhances communication between the "users" of environmental technologies and the Army's RDT&E community. It gives the RDT&E community a better understanding of users' environmental technology requirements with associated "closeout" criteria, their priorities, and the Army's cost of living with the problem, all of which provide the basis for developing RDT&E management plans. Army installations have better information on the development and availability of faster and more cost-effective environmental technologies. Organizations with technology requirements can use AERTA to identify and share "lessons learned" in a time of shrinking resources.

## Technology Users

Army and DoD major commands and installations using technologies to satisfy their environmental requirements. The AERTA Web site documents technology needs from four user communities: (1) users responsible for installation infrastructure; (2) users responsible for weapons systems acquisition; (3) major commands that use these weapons systems; and (4) agencies responsible for collecting and tracking needs related to infrastructure and weapons systems.

## Description

From 1992 to 1994, meetings were held to facilitate the collection and development of an initial database of approximately 200 environmentally related operational problems throughout the Army. The list of requirements was screened to focus on those requiring long-term research and development, then validated and prioritized through a voting process based on six ranking criteria: (1) environmental impact; (2) impact on readiness; (3) annual cost of operating with the unresolved requirement; (4) extent of the problem throughout the Army; (5) impact on quality of life; and (6) regulatory time limits.

The Office of the Assistant Chief of Staff for Installation Management (ACSIM), through the U.S. Army Environmental Center (USAEC), refined and updated these requirements from 1995 through 1997, expanding the scope of the effort into the Technology User Needs Survey (TNS). The Army's environmental databases were analyzed to maximize existing user environmental reporting and several site visits were conducted across Army installations and major commands. These actions refined the qualitative and quantitative data on user needs and allowed requirements to be compiled in a common format that supports the DoD Tri-Service Environmental Quality Requirements Strategy (prepared by ESTRG). The updated requirements were presented at technology team meetings in 1996 and 1997 for review and validation. The list was narrowed to 142 requirements, which were prioritized within each program area (i.e., pillar) by the user community.

The TNS was retailored as a Web site, enhanced to include off-the-shelf and developing technology information, and renamed AERTA. AERTA is a "living" document/database that is continuously refined according to the ACSIM's

user-requirements process and schedule. As the technology teams develop and execute RDT&E programs in response to these needs, the user representatives and stakeholders will adjust the need statement and exit criteria/metrics (i.e., measurements for determining when the need is considered completely satisfied). On a biennial basis, the user representatives will assess each program area to determine if a readjustment of the need statements, prioritization, exit criteria and supporting documentation is warranted. Completion of the first cycle for user-requirement development is anticipated for April 1999. Users may eventually be able to submit additional needs and associated data, within ACSIM guidelines, online.

An electronic copy of the Army's environmental technology needs can be reviewed on the Defense Environmental Network and Information eXchange (DENIX) at www.denix.cecer.army.mil/denix/DOD/Policy/Army/Aerta/default.html. The advantage of storing information on the DENIX Web site is that access is restricted to DoD employees and contractors with approved accounts and passwords. To address problems of data management and satisfy the concerns of having certain sensitive information exposed to the public, USAEC prepares two versions of the Army's environmental technology requirements on the World Wide Web. The first version contains unfiltered information and is maintained on the DENIX Web site. A second version, from which "sensitive" information not readily needed by the public has been deleted, is on the ESTRG Web site at xre22.brooks.af.mil/estrg/estrgtop.htm. The Office of the Secretary of Defense (OSD) ESTRG site will also identify primary points of contact (one to two per program area, per service) as a gateway for interested parties outside DoD.

## Accomplishments and Results

The AERTA process is ongoing. The requirements portion of AERTA is updated biennially, with the technology assessments portion updated quarterly.

## Limitations

The technology teams are responsible for screening out needs for which the solutions clearly do not involve technology.

**Point of Contact**

Erik Hangeland

**Program Partners**

U.S. Army Environmental Center
Members of the Army RDT&E community
Army technology users

**Publications**

*Army Technology Needs Survey.*

*Army Environmental Requirements and Technology Assessments.* World Wide Web site (www.denix.cecer.army.mil/denix/DoD/Policy/Army/Aerta/default.html).

## U.S./Germany Environmental Technology Data Exchange Agreement

Through Data Exchange Agreements (DEAs), the United States and other countries can share technical expertise and data to tackle common challenges and improve quality of life. The Department of Defense has administered an environmental technology exchange agreement with Germany for more than a decade.

**Purpose**

To promote sharing of environmental research and development (R&D) information among engineers and scientists of the U.S. and Germany. The agreement's focus was expanded in 1994 to include joint field demonstrations.

**Benefits**

Sharing information and expertise will benefit technology research and development efforts, and save R&D costs.

**Description**

Through DEAs, the United States and other countries can share technical expertise and data to tackle common challenges and improve quality of life. The Department of Defense has administered an environmental technology DEA with Germany since 1986. Under the agreement, the U.S. and Germany may share environmental information directly. In addition to this regular activity, the technical project officers of each DEA participate in periodic progress reviews, and general exchange meetings are held every 18 months. Meeting locations alternate between U.S. and German hosts.

The U.S./Germany environmental technology DEA consists of four individual agreements:

- DEA 1311, Hazardous Materials/Pollution Prevention/Air;
- DEA 1520, Soil Remediation;
- DEA 1521, Water Remediation;
- DEA 1522, Demilitarization and Disposal of Conventional Munitions.

The U.S. Army Environmental Center (USAEC) takes a leadership role as the Soils DEA technical project officer, or representative of all U.S. military agencies doing

environmental research or development work on soils characterization and remediation.

**ACCOMPLISHMENTS AND RESULTS**

In addition to sharing valuable scientific data and lessons learned, USAEC has sponsored a cooperative U.S./Germany field demonstration of Site Characterization and Analysis Penetrometer System (SCAPS) technology at Rhein Main Air Base, Germany.

**FOLLOW-ON PROGRAM REQUIREMENTS**

Continue to support international environmental technology transfer.

**POINT OF CONTACT**

Mark Hampton

**PROGRAM PARTNERS**

Deputy Assistant Secretary of the Army for Environment, Safety and Occupational Health (U.S. general officer for the DEA)

U.S. Army Edgewood Chemical and Biological Center (U.S. DEA project officer)

U.S. Army Environmental Center, Pollution Prevention and Environmental Technology Division (DEA 1520)

U.S. Army Armament Research, Development and Engineering Center (DEAs 1311 and 1522)

U.S. Air Force Research Lab (DEA 1521)

Federal Office for Defense Technology and Procurement (German DEA project officer)

German Federal Armed Forces Scientific Institute for Protection Technologies (German technical project officer for DEA 1520)

**PUBLICATIONS**

*Proceedings of the 1997 Environmental Technology Data Exchange Meeting.* April 1998.

## UXO Forum

In a concerted effort to bring together the best minds from all corners of the world, the annual UXO Forum addresses technology, policy and regulatory issues related to unexploded ordnance. Participants acquire a greater understanding of UXO issues, how they affect our world today, and the implications for the 21st century.

**Purpose**

To produce, manage and host a conference that addresses unexploded ordnance (UXO) technology, policy and regulatory issues.

**Benefits**

The conference brings together a diverse audience from around the world to exchange ideas and information on UXO.

**Description**

The UXO Forum addresses technology, policy and regulatory issues related to unexploded ordnance.

UXO Forum 1998 was sponsored by the U.S. Department of Defense Explosives Safety Board (DDESB) and hosted by the U.S. Army Environmental Center (USAEC), in cooperation with the Joint UXO Coordination Office, the U.S. Army Corps of Engineers-Huntsville Division, the U.S. Army Project Manager for Non-Stockpile Chemical Material, the Naval Explosive Ordnance Disposal Technology Division, the U.S. Air Force Wright Laboratory and the National Association of Ordnance and Explosive Waste Contractors. The DDESB will sponsor UXO Forum 1999.

**Accomplishments and Results**

USAEC produced and hosted UXO Forum 1998 in Anaheim, California, from May 5-7, 1998. Approximately 450 individuals attended.

**Follow-On Program Requirements**

Plan and conduct UXO Forum 1999 at the Renaissance Waverly Hotel, Atlanta, Georgia, from May 25-27, 1999.

**POINT OF CONTACT** Darlene Edwards

**PROGRAM PARTNERS**

U.S. Army Environmental Center
U.S. Department of Defense Explosives Safety Board
Unexploded Ordnance Center of Excellence
U.S. Army Corps of Engineers-Huntsville Division
U.S. Army Project Manager for Non-Stockpile Chemical Material
Naval Explosive Ordnance Disposal Technology Division
U.S. Air Force Wright Laboratory
National Association of Ordnance and Explosive Waste Contractors
Headquarters, U.S. Army Corps of Engineers R&D

**PUBLICATIONS** UXO Forum 1997 and 1998 conference proceedings.

# APPENDIX A

## Acronyms

ABRP – Agriculture-Based Bioremediation Program
ACSIM – Assistant Chief of Staff for Installation Management (Army)
ADPA – American Defense Preparedness Association
AERTA – Army Environmental (User) Requirements and Technology Assessments
AFCEE – Air Force Center for Environmental Excellence
AFF – Automated field fire
AFSPA – Air Force Security Police Agency
APG – Aberdeen Proving Ground, Maryland
AR – Army Regulation
ARDEC – U.S. Army Armament Research Development and Engineering Center
ARF – Automated record fire
ARL – U.S. Army Research Laboratory
ASAP – Army Sampling and Analysis Plan
ASARC – Army Systems Acquisition Review Council
ASTM – American Society for Testing and Materials
ATSC – U.S. Army Training Support Center
ATTACC – Army Training and Testing Area Carrying Capacity

BAA – Broad Agency Announcement
BRAC – Base Realignment and Closure
BTEX – Benzene, toluene, ethylbenzene and xylene

CA-WIPT – Cost Analysis Working-Level Integrated Product Team
CDFs – Cost documentation formats
CEAC – U.S. Army Cost and Economic Analysis Center
CERL – U.S. Army Engineer Research and Development Center-Construction Engineering Research Laboratories
CE-MP – U.S. Army Corps of Engineers Military Programs Office
CEQ – Council on Environmental Quality
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act
CFM – Cubic feet per minute
CFR – Code of Federal Regulations
CHPPM – Army Center for Health Promotion and Preventive Medicine
CONUS – Continental United States
CPQC – Combat pistol qualification course
CRADA – Cooperative Research and Development Agreement
CRREL – U.S. Army Engineer Research and Development Center-Cold Regions Research and Engineering Laboratory
CSCT – Consortium for Site Characterization Technology (EPA)

CTC – Concurrent Technologies Corporation
CWA – Clean Water Act
CX – Categorical Exclusion

DDESB – Department of Defense Explosives Safety Board
DEA – Data Exchange Agreement
DENIX – Defense Environmental Network and Information eXchange
DESCIM – Defense Environmental Security Corporate Information Management
DoD – Department of Defense
DOE – Department of Energy
DSERTS – Defense Site Environmental Restoration Tracking System

EA – Environmental Assessment
EDYS – Dynamics simulation model
EIS – Environmental Impact Statement
EO – Executive Order
EOD – Explosive Ordnance Disposal
EPA – Environmental Protection Agency
EPCRA – Emergency Planning and Community Right-to-Know Act
EPP – Environmentally preferable product
ESH – Environmental, safety and health (evaluations)
ESTCP – Environmental Security Technology Certification Program
ESTRG – Environmental Security Technology Requirements Group

FONSI – Finding of No Significant Impact
FORSCOM – U.S. Army Forces Command
FRH – Fire resistant hydraulic fluid
FRTR – Federal Remediation Technologies Roundtable
FUDS – Formerly Used Defense Sites

GAC – Granular activated carbon
GMF – Granular media filter
GMS – Groundwater Modeling System
gpm – Gallons per minute

HAP – Hazardous air pollutant
HEPA – High efficiency particulate air
HGD – Hot Gas Decontamination
HM – Hazardous materials
HMMP – Hazardous Material Management Program
HMX – Cyclotetramethylene
HS – HydroSparge sensor (SCAPS)
HSMS – Hazardous Substance Management System
HTRW-CX – Hazardous, Toxic, and Radioactive Waste Center of Expertise
HW – Hazardous waste

IAAAP – Iowa Army Ammunition Plant
IOC – U.S. Army Industrial Operations Command
ITAM – Integrated Training Area Management
ITMS – Ion trap mass spectrometer
ITRC – Interstate Technology Regulatory Cooperation Workgroup

JOAAP – Joliet Army Ammunition Plant, Illinois

KCF – Kansas City Facility (DOE)

LANL – Los Alamos National Laboratory (DOE)
LAP – Load, assemble and pack
LBCC – Land-Based Carrying Capacity
LCAAP – Lake City Army Ammunition Plant, Missouri
LCTA – Land Condition Trend Analysis (ITAM)
LIBS – Laser Induced Breakdown Spectroscopy
LIF – Laser Induced Fluorescence sensor (SCAPS)

MAAP – Milan Army Ammunition Plant, Tennessee
MACOM – Major Army command
MCAAP – McAlester Army Ammunition Plant, Oklahoma

NAPL – Non-aqueous phase liquid
NATO – North Atlantic Treaty Organization
NAWS – Naval Air Weapons Station
NDCEE – National Defense Center for Environmental Excellence
NDIA – National Defense Industry Association
NEPA – National Environmental Policy Act
NFESC – Naval Facilities Engineering Service Center
NRCS – Natural Resources Conservation Service
NSWC – Naval Surface Warfare Center

OCONUS – Outside the Continental United States
ODEP – Office of the Director of Environmental Programs (Army)
ORNL – Oak Ridge National Laboratory
OSD – Office of the Secretary of Defense
OWS – Oil/water separator

P2 – Pollution prevention
P2IF – Pollution Prevention Investment Fund
PAM – Polyacrylamide
PEO – Program executive officer
PEPS – Plasma Energy Pyrolysis System
PM – Program manager
POLs – Petroleum, oils and lubricants
POM – Program Objective Memorandum

ppb – Parts per billion
ppm – Parts per million

R&D – Research and Development
R3M – Range Rule Risk Model
RBCA – Risk Based Corrective Action
RCRA – Resource Conservation and Recovery Act
RDT&E – Research, Development, Test and Evaluation
RDX – Cyclonite
REC – Record of Environmental Consideration
REST – Range Evaluation Software Tool
ROD – Record of Decision
RUSLE – Revised Universal Soil Loss Equation

SABRE – Simplot Anaerobic Bioremediation Ex-situ (bioslurry) process
SACON – Shock Absorbing Concrete
SADARM – Sense and Destroy Armor
SCAPS – Site Characterization and Analysis Penetrometer System
SITE – Superfund Innovative Technology Evaluation (EPA)
SMART-T – Secure Mobile Anti-Jam Reliable Tactical Terminal
SOW – Statement of Work
SVE – Soil vapor extraction

TACOM – U.S. Army Tank-automotive and Armaments Command
TC – Training Circular
TCA – Tactical Concealment Area
TCAAP – Twin Cities Army Ammunition Plant, Minnesota
TCE – Trichloroethylene
TDS – Thermal Desorption Sampler (SCAPS)
TNS – Technology (User) Needs Survey
TNT – Trinitrotoluene
TPH – Total petroleum hydrocarbons
TRADOC – U.S. Army Training and Doctrine Command
TVA – Tennessee Valley Authority

USAATC – U.S. Army Aberdeen Test Center
USAEC – U.S. Army Environmental Center
USAIC – U.S. Army Infantry Center
USMA – U.S. Military Academy
UXO – Unexploded ordnance

VOC – Volatile organic compound
VTC – Vertical tube coalescer

WES – U.S. Army Engineer Research and Development Center-Waterways Experiment Station

XRF – X-Ray Fluorescence sensor (SCAPS)

# APPENDIX B

## Program Partners

P2&ETD specialists often team up with experts from across the Army, Navy, Air Force, Department of Defense, other federal and state government agencies, private industry and academia. Our partners include:

AFL Industries
Air Force Center for Environmental Excellence
Alliant TechSystems
Anniston Army Depot, Alabama
Argonne National Laboratory
Arizona Army National Guard

Battelle Columbus Operations

Camp Bullis, Texas
Camp Guernsey, Wyoming
Camp Ripley, Minnesota
Combat Training Support Directorate, Deputy Chief of Staff-Training, Training and Doctrine Command
Concurrent Technologies Corporation
Corpus Christi Army Depot, Texas

Defense Evaluation Support Activity
Department of Defense Environmental Security Technology Certification Program
Deputy Assistant Secretary of the Army for Environment, Safety and Occupational Health
Deputy Under Secretary of Defense for Environmental Security
Dugway Proving Ground, Utah

Environmental Security Technology Certification Program

Federal Office for Defense Technology and Procurement (Germany)
Federal Remediation Technologies Roundtable
Fort Bliss, Texas
Fort Campbell, Kentucky
Fort Carson, Colorado
Fort Hood, Texas
Fort Jackson, South Carolina
Fort Knox, Kentucky
Fort Leonard Wood, Missouri
Fort McPherson, Georgia

Fort Pickett, Virginia
Fort Rucker, Alabama
Fort Stewart, Georgia

German Federal Armed Forces Scientific Institute for Protection Technologies

Iowa Army Ammunition Plant, Iowa

Joliet Army Ammunition Plant, Illinois

Lake City Army Ammunition Plant, Missouri
Landa Incorporated

McAlester Army Ammunition Plant, Oklahoma
Milan Army Ammunition Plant, Tennessee

National Association of Ordnance and Explosive Waste Contractors
National Defense Center for Environmental Excellence
National Guard Bureau
Natural Resources Conservation Service
Naval Aviation Depot – Cherry Point, North Carolina
Naval Explosive Ordnance Disposal Technology Division
Naval Facilities Engineering Service Center

Oak Ridge National Laboratory
Office of the Assistant Secretary of the Navy for Installations and Environment
Office of the Director of Environmental Programs (Army)
Orchard Training Area, Idaho

Pacific Northwest National Laboratories
Pall Aerospace
Parsons Engineering Science, Inc.
Patuxent River Naval Air Station, Maryland
Plasma Energy Applied Technology
Platinum International, Inc.
Point Mugu Naval Air Weapons Station, California
Program Executive Office-Standard Army Management Information Systems, HSMS Project Office
Program Manager-Apache helicopter program
Program Manager-Comanche helicopter program
Program Manager-Secure Mobile Anti-Jam Reliable Tactical Terminal (SMART-T)
Program Manager-Sense and Destroy Armor (SADARM)

Range Rule Partnering Initiative
RGF Environmental Group

Strategic Environmental Research and Development Program

Teledyne Brown Engineering
Tennessee Valley Authority
The Boeing Company
TRW Systems Integration Group
Twin Cities Army Ammunition Plant, Minnesota

U.S. Air Force
U.S. Air Force Wright Laboratory
U.S. Army Aberdeen Test Center
U.S. Army Armament Research Development and Engineering Center
U.S. Army Corps of Engineers (Headquarters)
U.S. Army Corps of Engineers-Huntsville Division
U.S. Army Cost and Economic Analysis Center
U.S. Army Edgewood Chemical and Biological Center
U.S. Army Engineer Research and Development Center-Cold Regions Research and Engineering Laboratory
U.S. Army Engineer Research and Development Center-Construction Engineering Research Laboratories
U.S. Army Engineer Research and Development Center-Topographic Engineering Center
U.S. Army Engineer Research and Development Center-Waterways Experiment Station
U.S. Army Engineering and Support Center, Huntsville
U.S. Army Forces Command
U.S. Army Garrison, Fort Lee, Virginia
U.S. Army Industrial Operations Command
U.S. Army Project Manager for Non-Stockpile Chemical Material
U.S. Army Research Laboratory
U.S. Army Space and Missile Defense Command
U.S. Army Tank-automotive and Armaments Command
U.S. Army Training and Doctrine Command
U.S. Army Training Support Center
U.S. Army, Pacific
U.S. Department of Agriculture
U.S. Department of Defense
U.S. Department of Defense Explosives Safety Board
U.S. Department of Energy
U.S. Environmental Protection Agency
U.S. Geological Survey
U.S. Marine Corps
U.S. Military Academy, New York
U.S. Navy
Unexploded Ordnance Center of Excellence

Vanguard Research Inc.

Warner-Robins Air Logistics Center, Georgia